FIG. 1

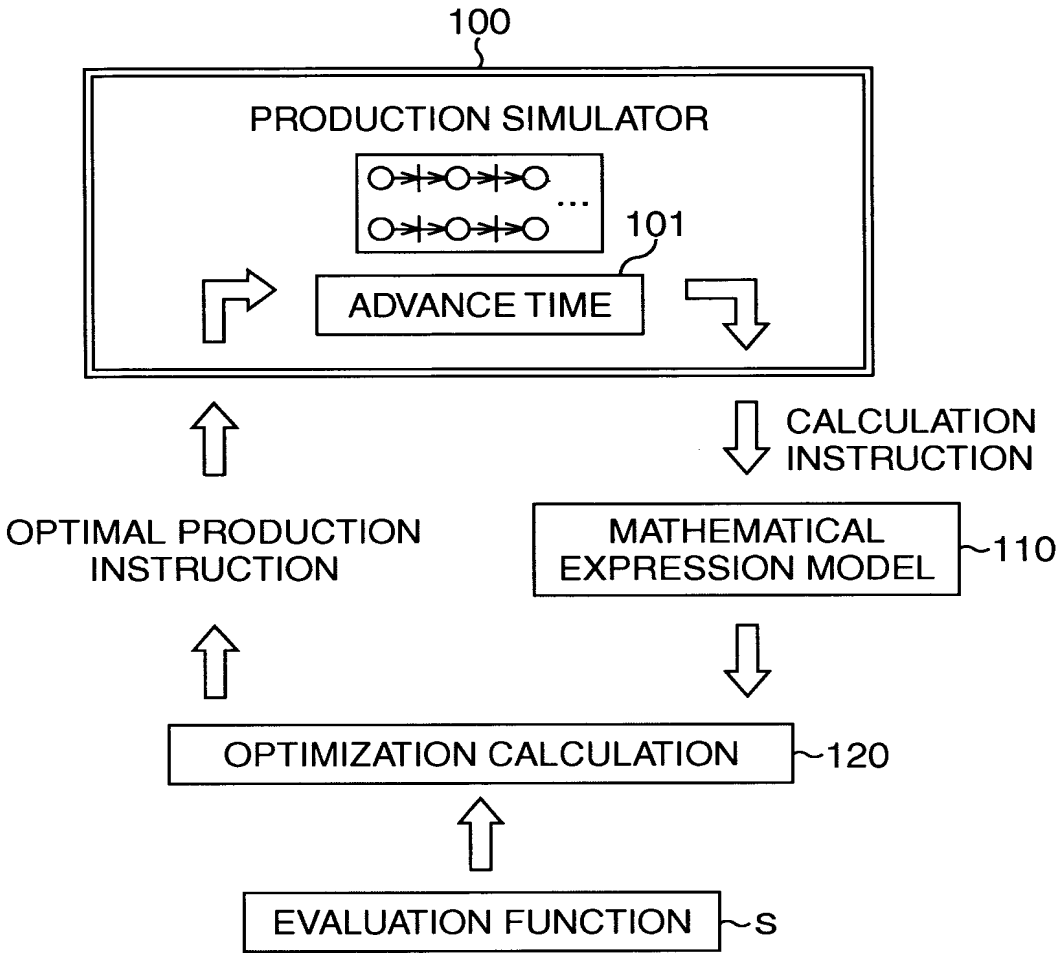


FIG. 2

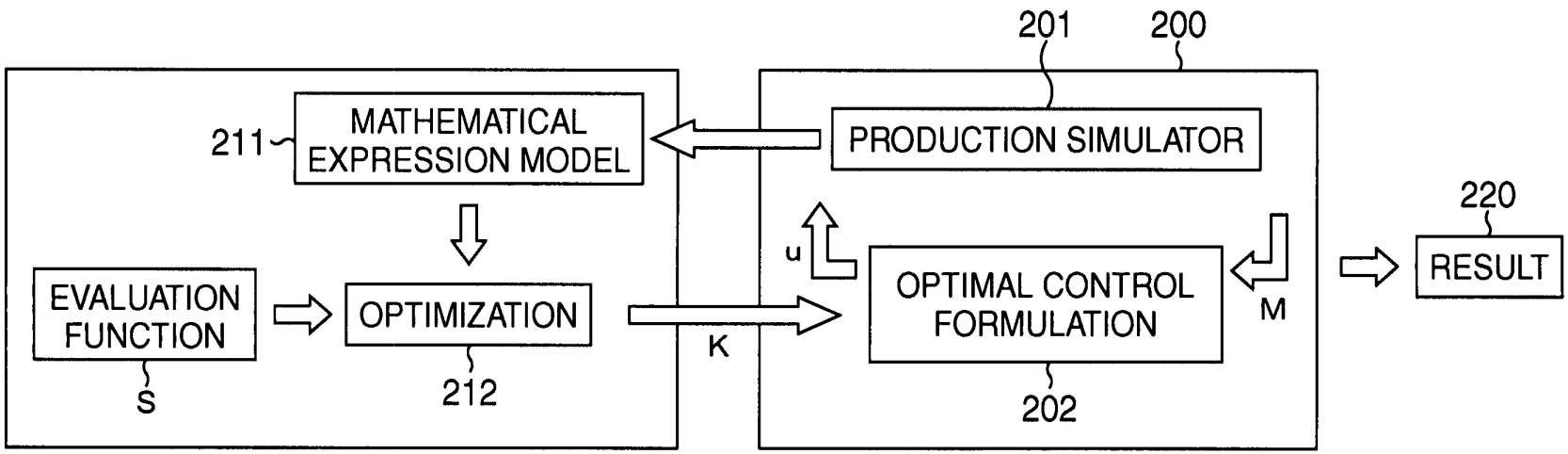

201
200
211
MATHEMATICAL EXPRESSION MODEL
PRODUCTION SIMULATOR
220
u
EVALUATION FUNCTION
OPTIMIZATION
OPTIMAL CONTROL FORMULATION
M
RESULT
K
S
212
202

FIG. 3

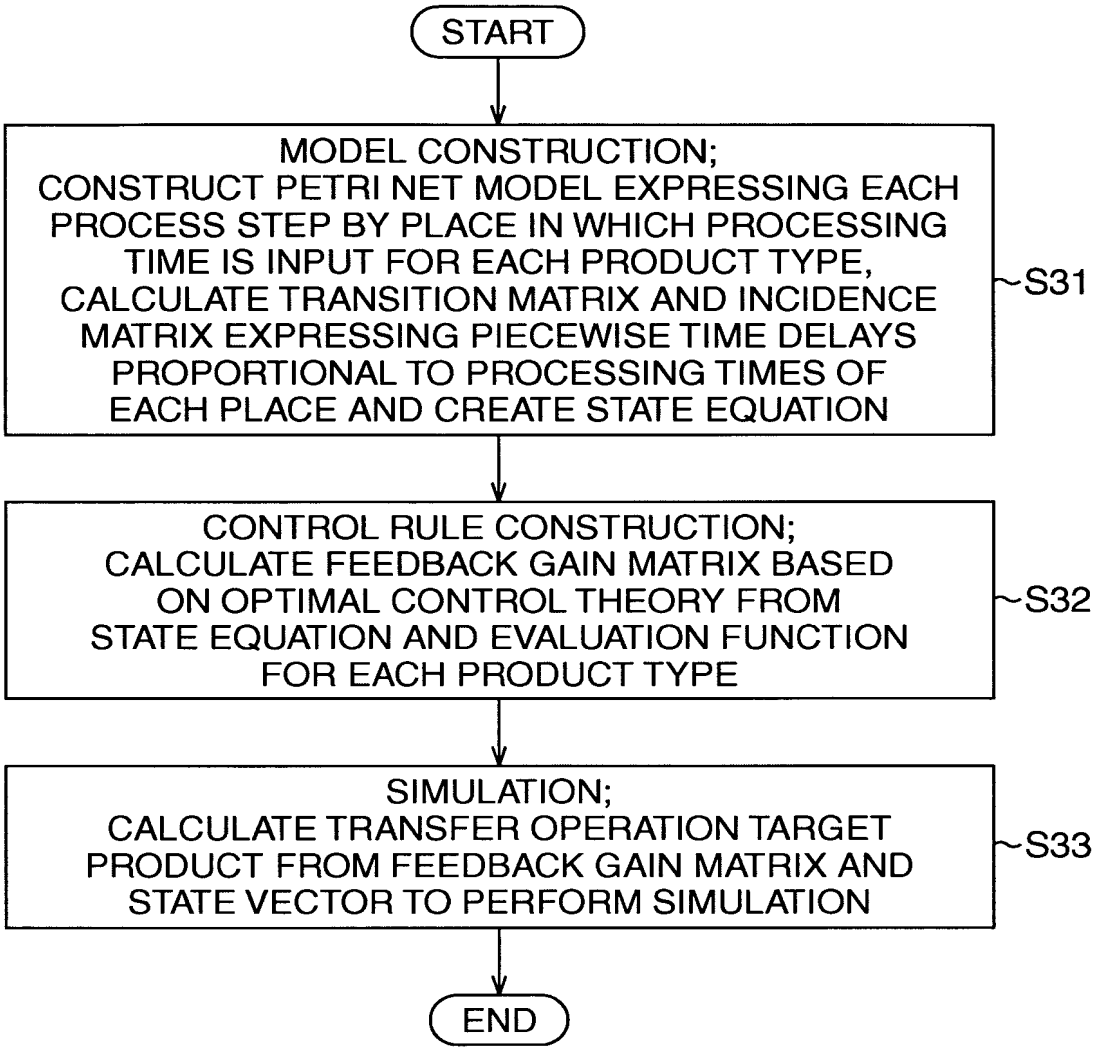

START
MODEL CONSTRUCTION;
CONSTRUCT PETRI NET MODEL EXPRESSING EACH PROCESS STEP BY PLACE IN WHICH PROCESSING TIME IS INPUT FOR EACH PRODUCT TYPE, CALCULATE TRANSITION MATRIX AND INCIDENCE MATRIX EXPRESSING PIECEWISE TIME DELAYS PROPORTIONAL TO PROCESSING TIMES OF EACH PLACE AND CREATE STATE EQUATION
S31
CONTROL RULE CONSTRUCTION;
CALCULATE FEEDBACK GAIN MATRIX BASED ON OPTIMAL CONTROL THEORY FROM STATE EQUATION AND EVALUATION FUNCTION FOR EACH PRODUCT TYPE
S32
SIMULATION;
CALCULATE TRANSFER OPERATION TARGET PRODUCT FROM FEEDBACK GAIN MATRIX AND STATE VECTOR TO PERFORM SIMULATION
S33
END

FIG. 4

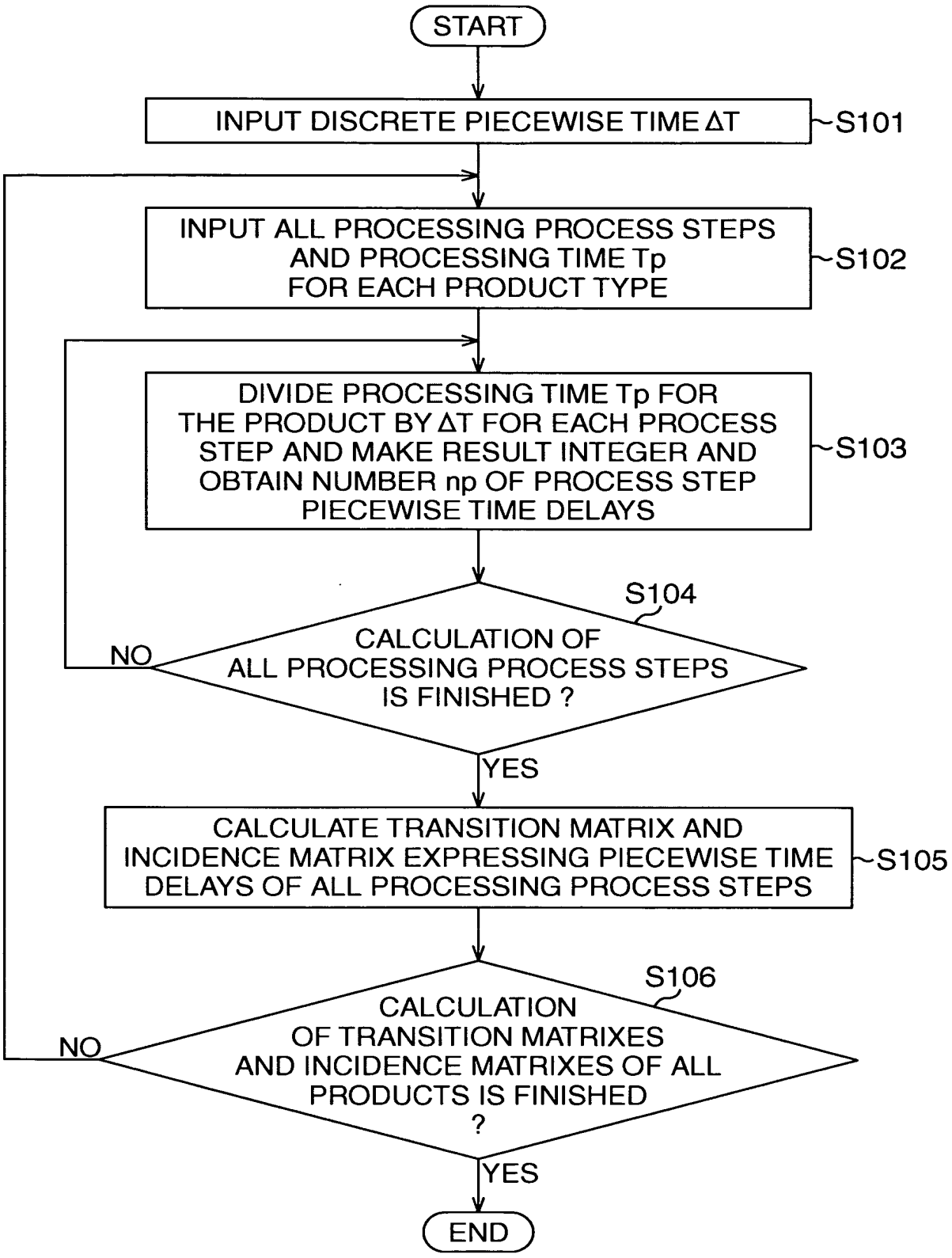

START
INPUT DISCRETE PIECEWISE TIME ΔT
S101
INPUT ALL PROCESSING PROCESS STEPS AND PROCESSING TIME Tp FOR EACH PRODUCT TYPE
S102
DIVIDE PROCESSING TIME Tp FOR THE PRODUCT BY ΔT FOR EACH PROCESS STEP AND MAKE RESULT INTEGER AND OBTAIN NUMBER np OF PROCESS STEP PIECEWISE TIME DELAYS
S103
S104
CALCULATION OF ALL PROCESSING PROCESS STEPS IS FINISHED ?
NO
YES
CALCULATE TRANSITION MATRIX AND INCIDENCE MATRIX EXPRESSING PIECEWISE TIME DELAYS OF ALL PROCESSING PROCESS STEPS
S105
S106
CALCULATION OF TRANSITION MATRIXES AND INCIDENCE MATRIXES OF ALL PRODUCTS IS FINISHED ?
NO
YES
END

FIG. 5

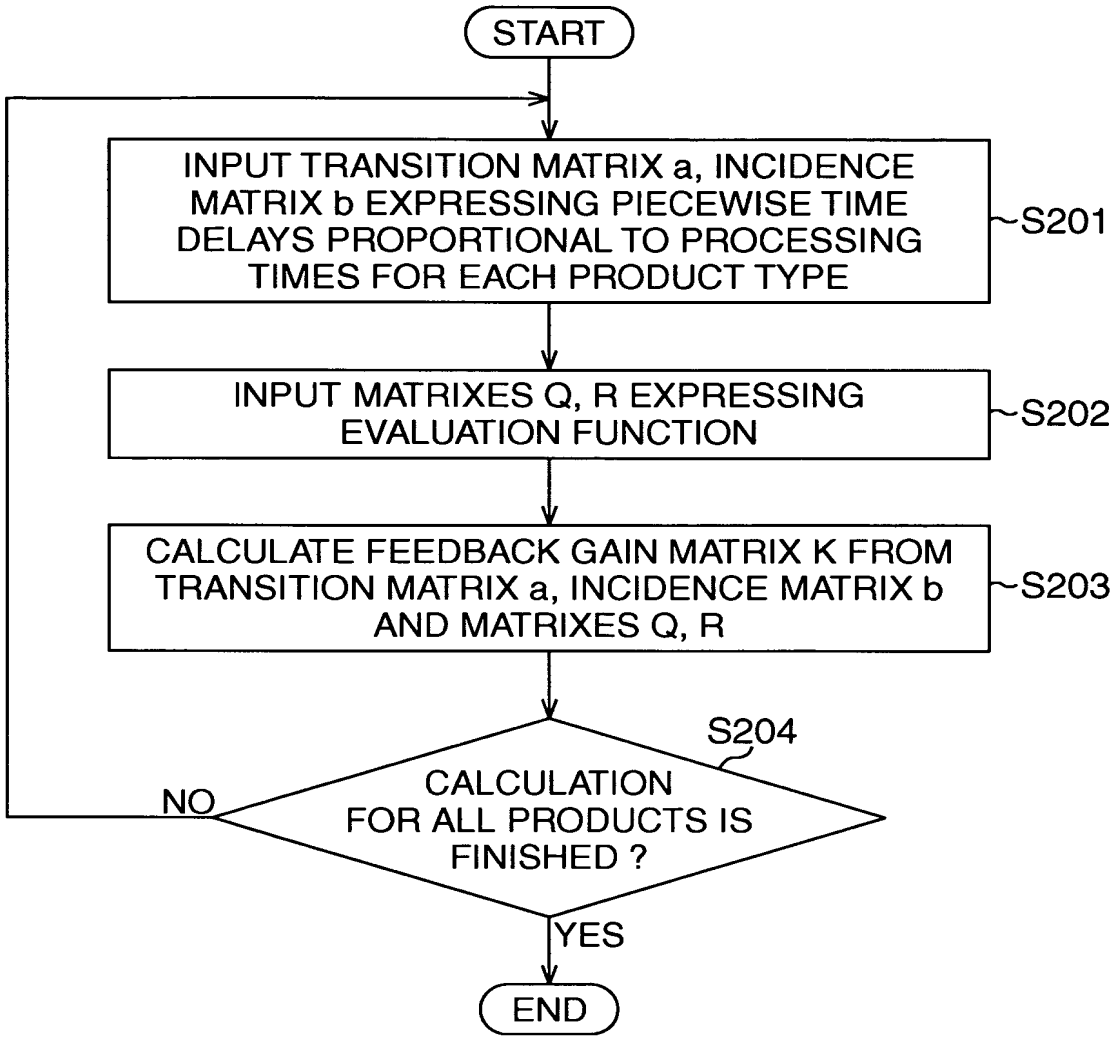

START
INPUT TRANSITION MATRIX a, INCIDENCE MATRIX b EXPRESSING PIECEWISE TIME DELAYS PROPORTIONAL TO PROCESSING TIMES FOR EACH PRODUCT TYPE
S201
INPUT MATRIXES Q, R EXPRESSING EVALUATION FUNCTION
S202
CALCULATE FEEDBACK GAIN MATRIX K FROM TRANSITION MATRIX a, INCIDENCE MATRIX b AND MATRIXES Q, R
S203
S204
CALCULATION FOR ALL PRODUCTS IS FINISHED ?
NO
YES
END

FIG. 6

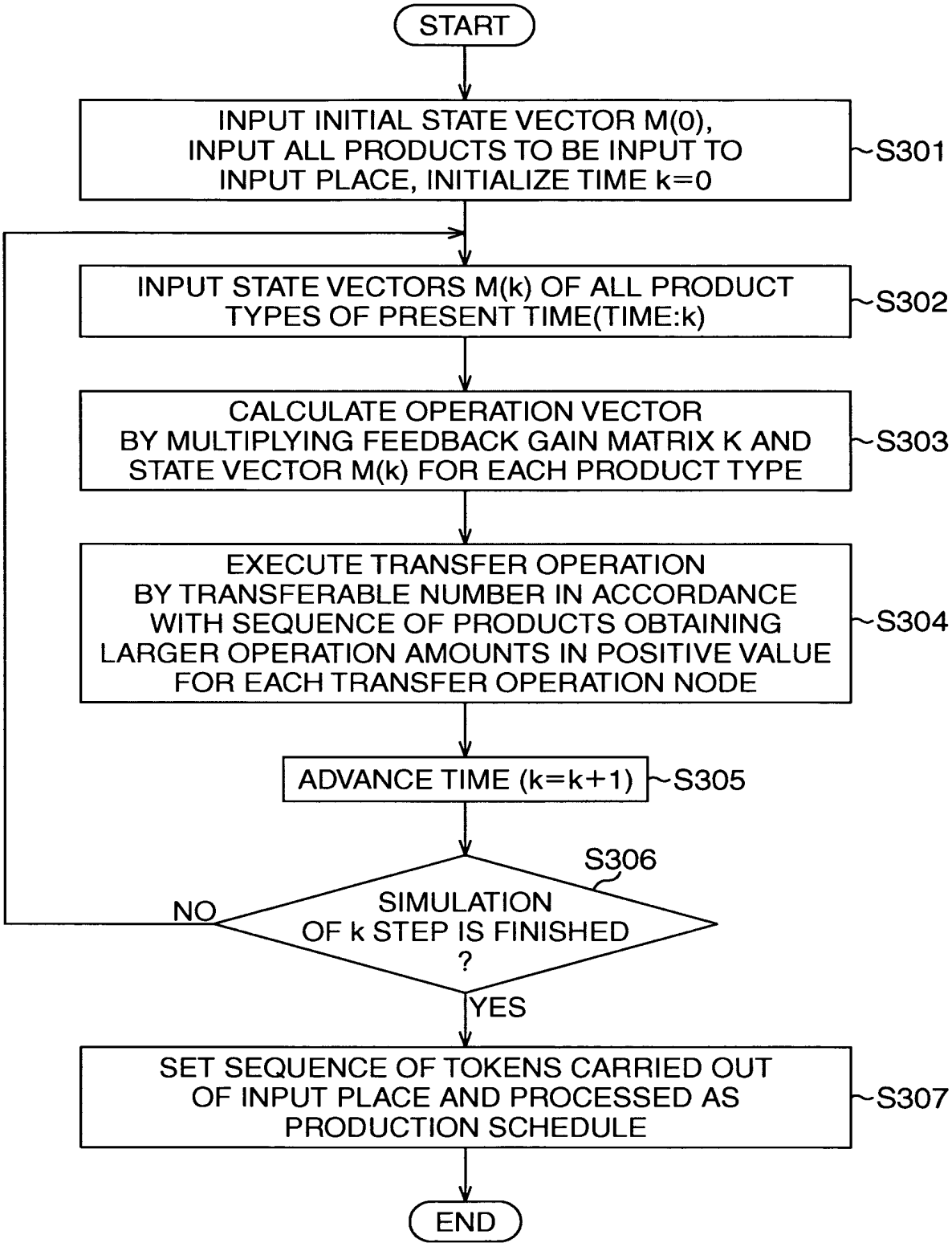

START
INPUT INITIAL STATE VECTOR M(0), INPUT ALL PRODUCTS TO BE INPUT TO INPUT PLACE, INITIALIZE TIME k=0
S301
INPUT STATE VECTORS M(k) OF ALL PRODUCT TYPES OF PRESENT TIME(TIME:k)
S302
CALCULATE OPERATION VECTOR BY MULTIPLYING FEEDBACK GAIN MATRIX K AND STATE VECTOR M(k) FOR EACH PRODUCT TYPE
S303
EXECUTE TRANSFER OPERATION BY TRANSFERABLE NUMBER IN ACCORDANCE WITH SEQUENCE OF PRODUCTS OBTAINING LARGER OPERATION AMOUNTS IN POSITIVE VALUE FOR EACH TRANSFER OPERATION NODE
S304
ADVANCE TIME (k=k+1)
S305
S306
SIMULATION OF k STEP IS FINISHED ?
NO
YES
SET SEQUENCE OF TOKENS CARRIED OUT OF INPUT PLACE AND PROCESSED AS PRODUCTION SCHEDULE
S307
END

FIG. 7

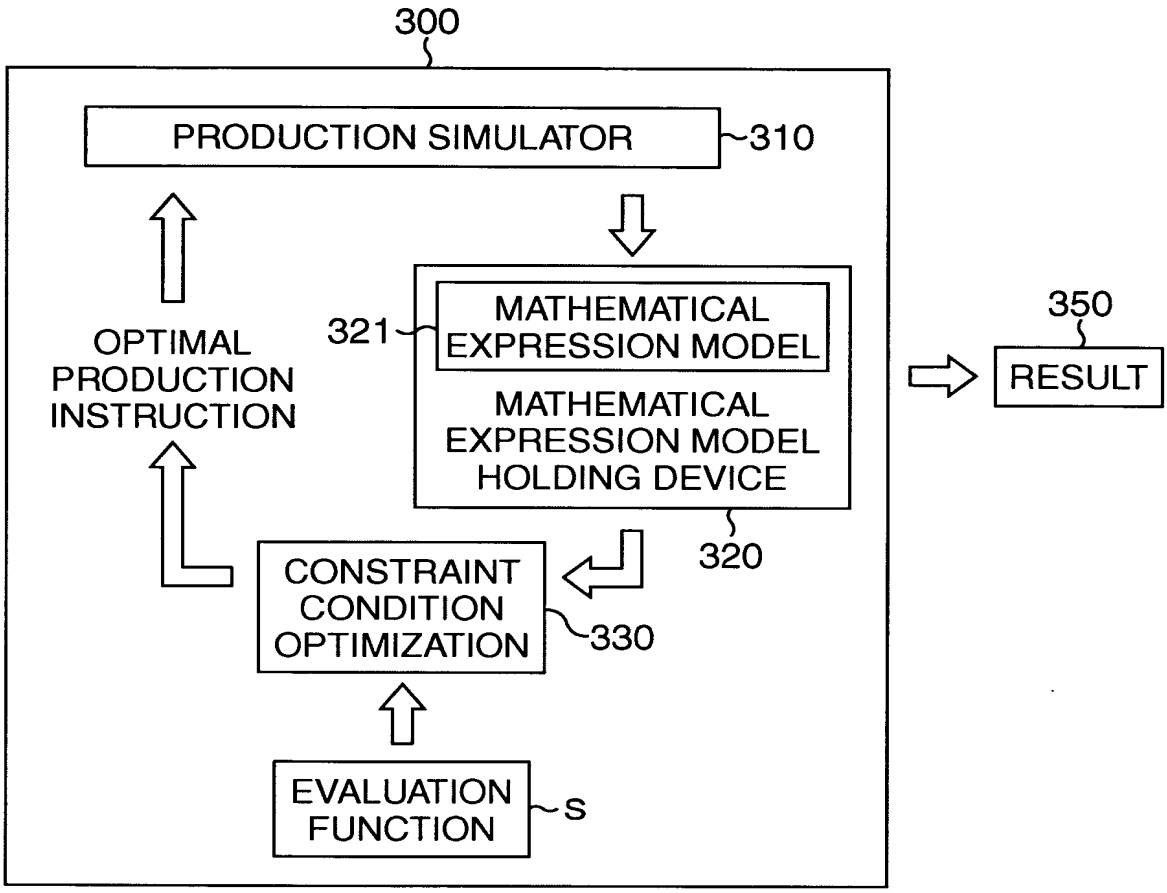

300
PRODUCTION SIMULATOR
310
OPTIMAL PRODUCTION INSTRUCTION
321
MATHEMATICAL EXPRESSION MODEL
MATHEMATICAL EXPRESSION MODEL HOLDING DEVICE
320
350
RESULT
CONSTRAINT CONDITION OPTIMIZATION
330
EVALUATION FUNCTION
S

FIG. 8

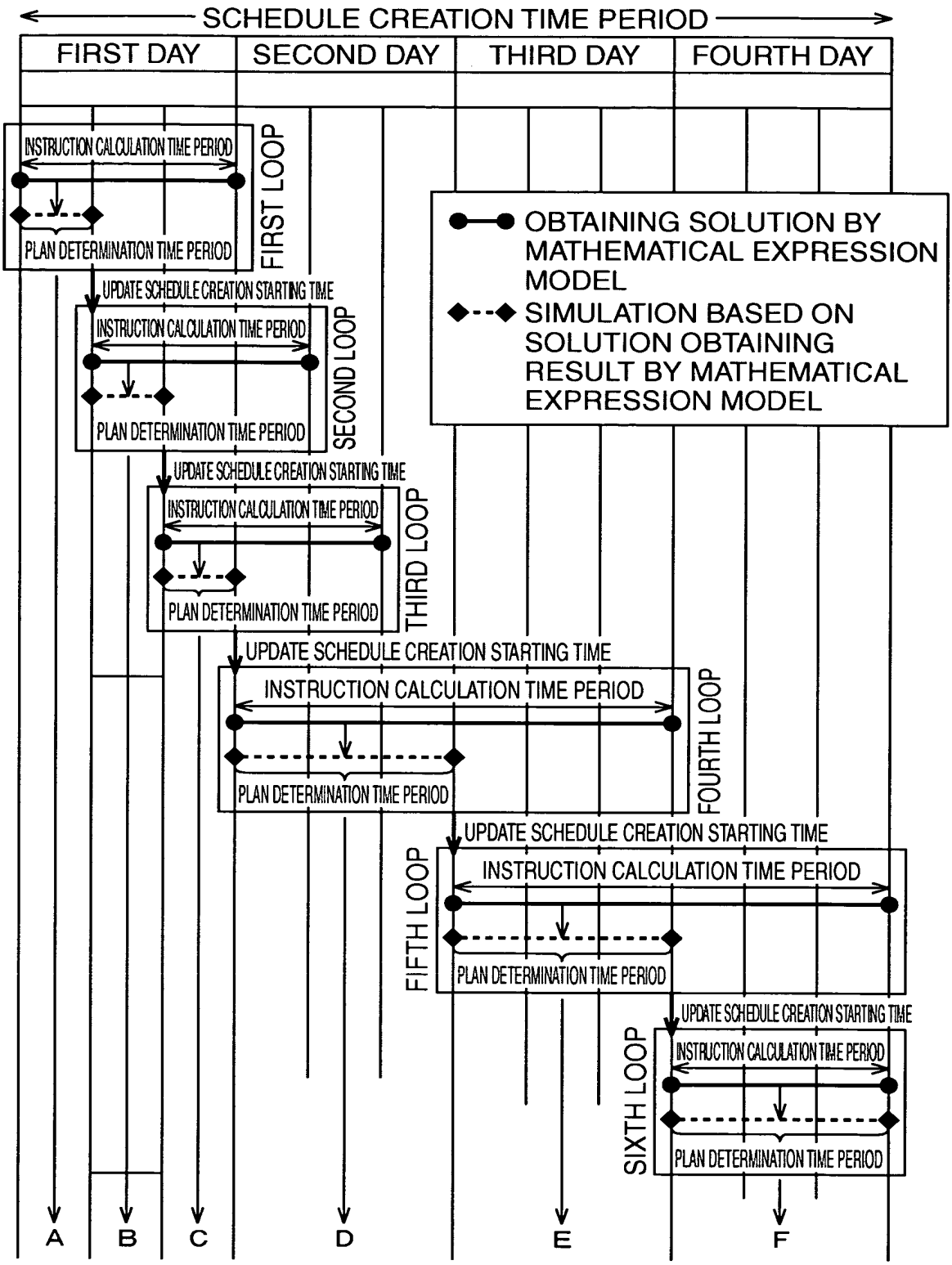

SCHEDULE CREATION TIME PERIOD
FIRST DAY
SECOND DAY
THIRD DAY
FOURTH DAY
INSTRUCTION CALCULATION TIME PERIOD
PLAN DETERMINATION TIME PERIOD
FIRST LOOP
UPDATE SCHEDULE CREATION STARTING TIME
SECOND LOOP
THIRD LOOP
FOURTH LOOP
FIFTH LOOP
SIXTH LOOP
OBTAINING SOLUTION BY MATHEMATICAL EXPRESSION MODEL
SIMULATION BASED ON SOLUTION OBTAINING RESULT BY MATHEMATICAL EXPRESSION MODEL
A
B
C
D
E
F

FIG. 9

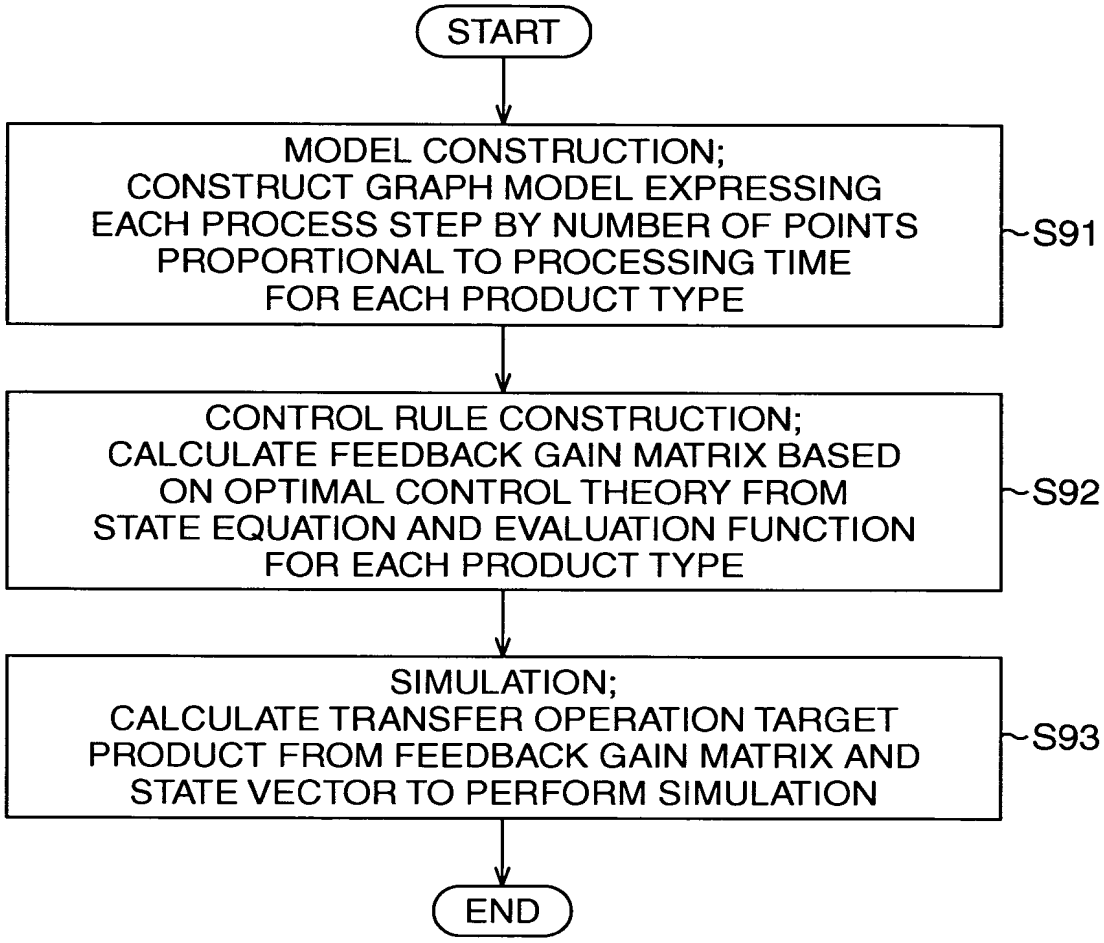

START
MODEL CONSTRUCTION;
CONSTRUCT GRAPH MODEL EXPRESSING
EACH PROCESS STEP BY NUMBER OF POINTS
PROPORTIONAL TO PROCESSING TIME
FOR EACH PRODUCT TYPE
S91
CONTROL RULE CONSTRUCTION;
CALCULATE FEEDBACK GAIN MATRIX BASED
ON OPTIMAL CONTROL THEORY FROM
STATE EQUATION AND EVALUATION FUNCTION
FOR EACH PRODUCT TYPE
S92
SIMULATION;
CALCULATE TRANSFER OPERATION TARGET
PRODUCT FROM FEEDBACK GAIN MATRIX AND
STATE VECTOR TO PERFORM SIMULATION
S93
END

FIG. 10

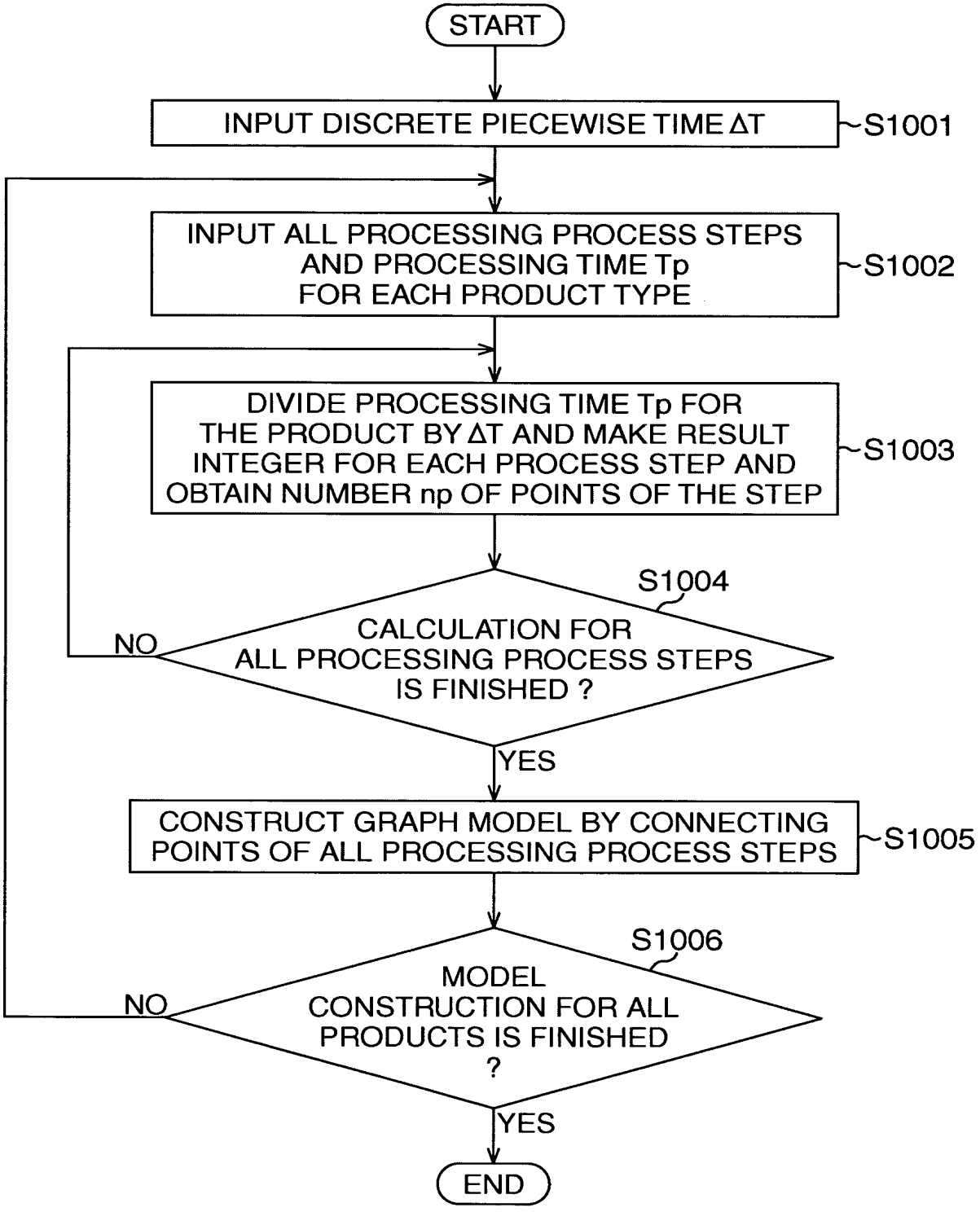

START
INPUT DISCRETE PIECEWISE TIME ΔT
S1001
INPUT ALL PROCESSING PROCESS STEPS AND PROCESSING TIME Tp FOR EACH PRODUCT TYPE
S1002
DIVIDE PROCESSING TIME Tp FOR THE PRODUCT BY ΔT AND MAKE RESULT INTEGER FOR EACH PROCESS STEP AND OBTAIN NUMBER np OF POINTS OF THE STEP
S1003
S1004
CALCULATION FOR ALL PROCESSING PROCESS STEPS IS FINISHED ?
NO
YES
CONSTRUCT GRAPH MODEL BY CONNECTING POINTS OF ALL PROCESSING PROCESS STEPS
S1005
S1006
MODEL CONSTRUCTION FOR ALL PRODUCTS IS FINISHED ?
NO
YES
END

FIG. 11

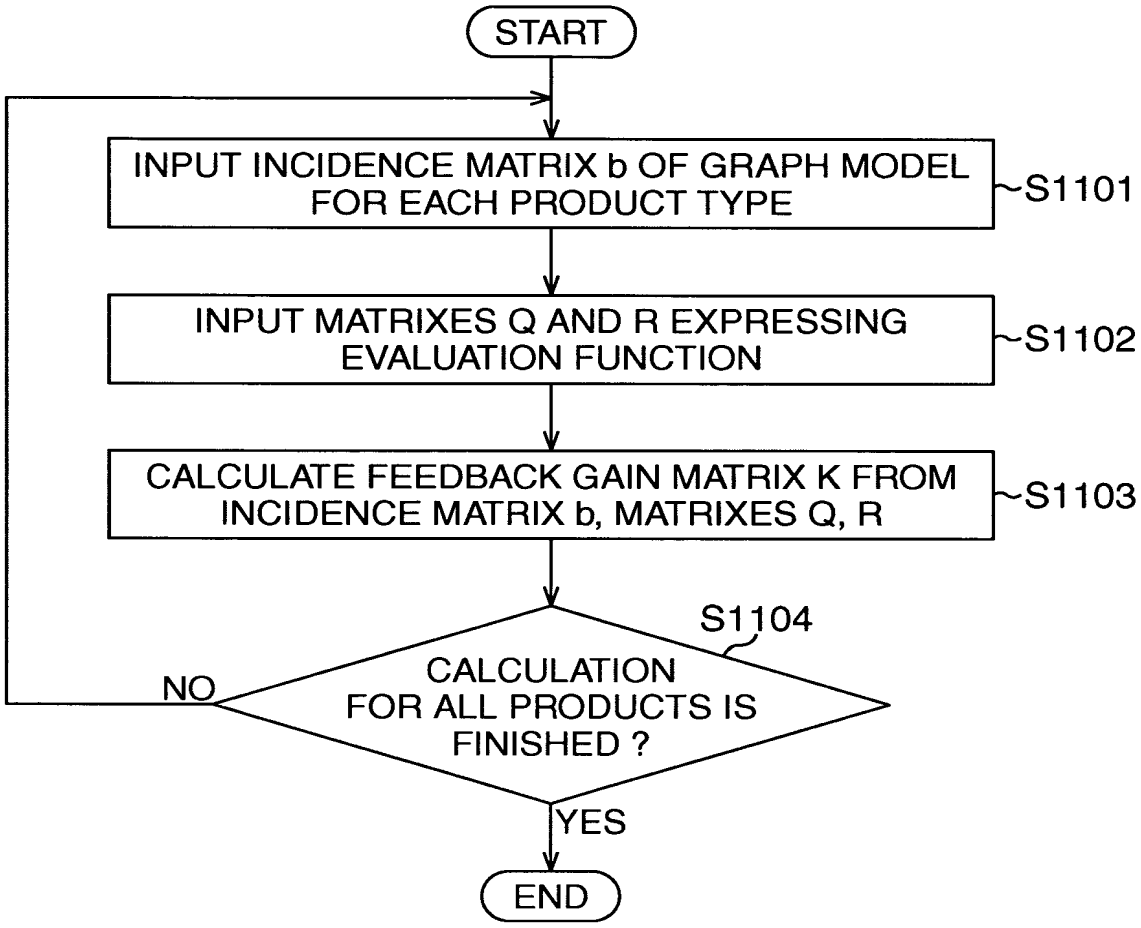

START
INPUT INCIDENCE MATRIX b OF GRAPH MODEL FOR EACH PRODUCT TYPE
S1101
INPUT MATRIXES Q AND R EXPRESSING EVALUATION FUNCTION
S1102
CALCULATE FEEDBACK GAIN MATRIX K FROM INCIDENCE MATRIX b, MATRIXES Q, R
S1103
S1104
CALCULATION FOR ALL PRODUCTS IS FINISHED ?
NO
YES
END

FIG. 12

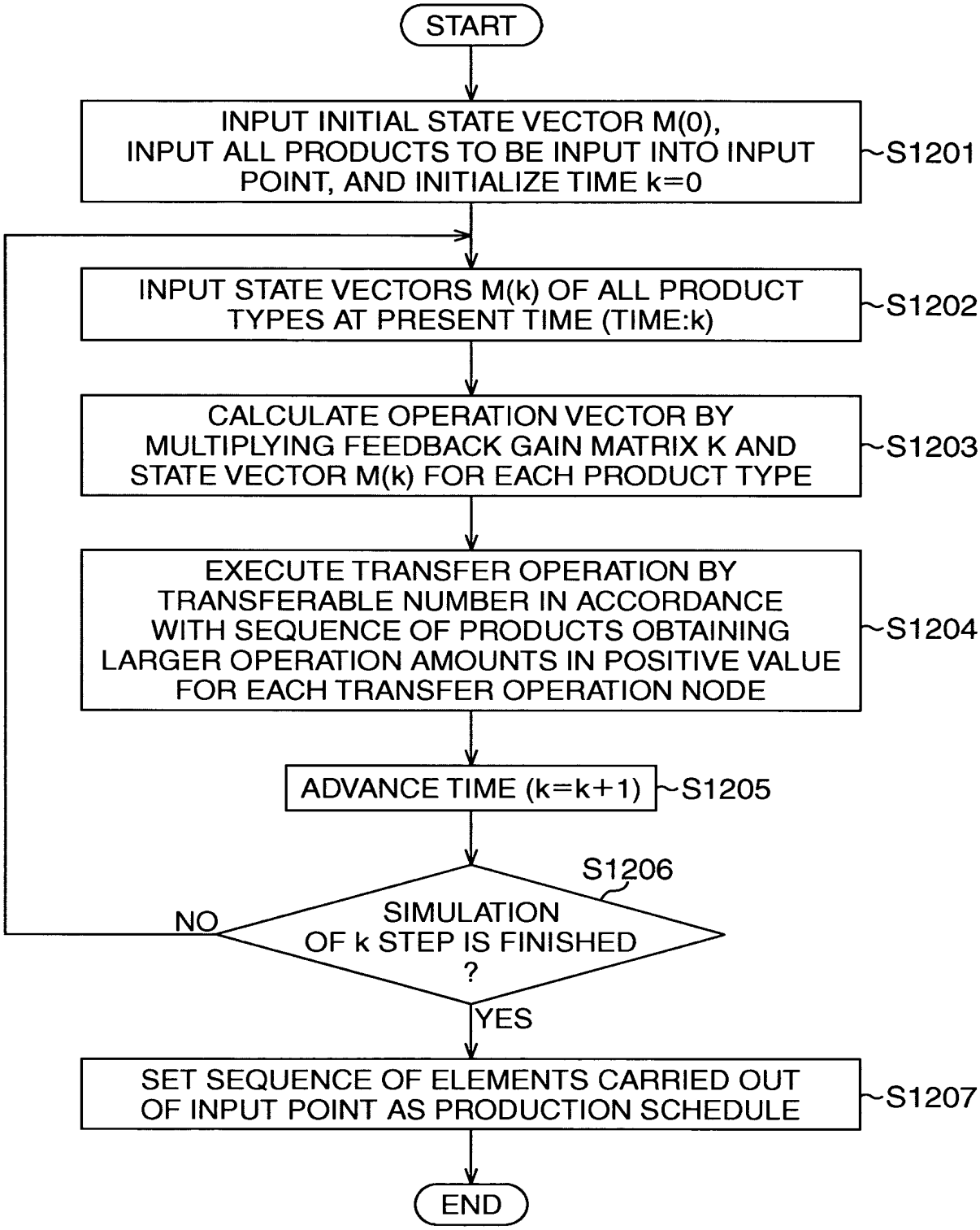

START
INPUT INITIAL STATE VECTOR M(0), INPUT ALL PRODUCTS TO BE INPUT INTO INPUT POINT, AND INITIALIZE TIME k=0
S1201
INPUT STATE VECTORS M(k) OF ALL PRODUCT TYPES AT PRESENT TIME (TIME:k)
S1202
CALCULATE OPERATION VECTOR BY MULTIPLYING FEEDBACK GAIN MATRIX K AND STATE VECTOR M(k) FOR EACH PRODUCT TYPE
S1203
EXECUTE TRANSFER OPERATION BY TRANSFERABLE NUMBER IN ACCORDANCE WITH SEQUENCE OF PRODUCTS OBTAINING LARGER OPERATION AMOUNTS IN POSITIVE VALUE FOR EACH TRANSFER OPERATION NODE
S1204
ADVANCE TIME (k=k+1)
S1205
S1206
SIMULATION OF k STEP IS FINISHED ?
NO
YES
SET SEQUENCE OF ELEMENTS CARRIED OUT OF INPUT POINT AS PRODUCTION SCHEDULE
S1207
END

FIG. 13

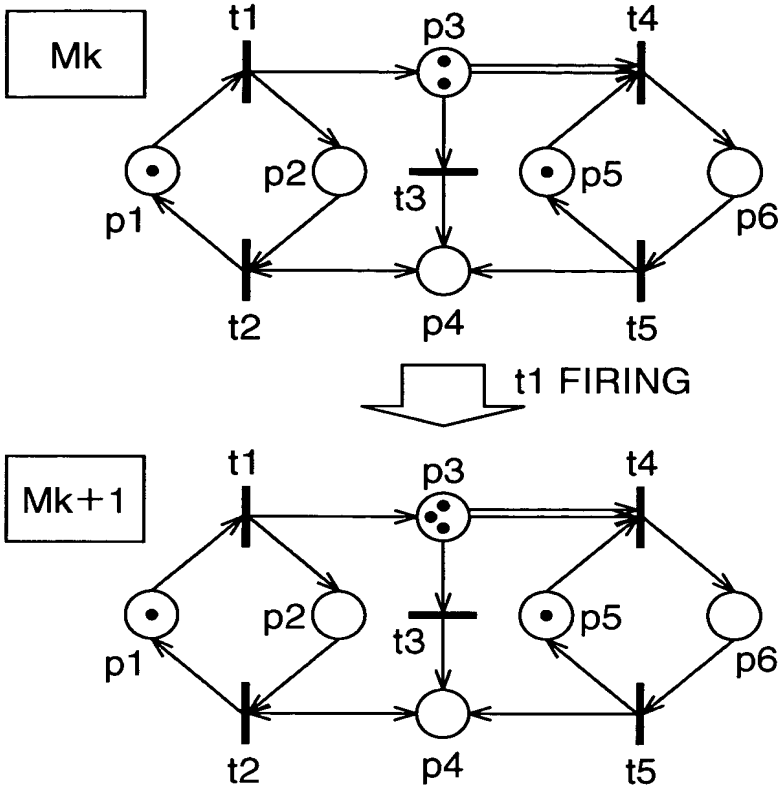

Mk
t1
p3
t4
p2
t3
p5
p1
p6
t2
p4
t5
t1 FIRING
Mk+1
t1
p3
t4
p2
t3
p5
p1
p6
t2
p4
t5

FIG. 14

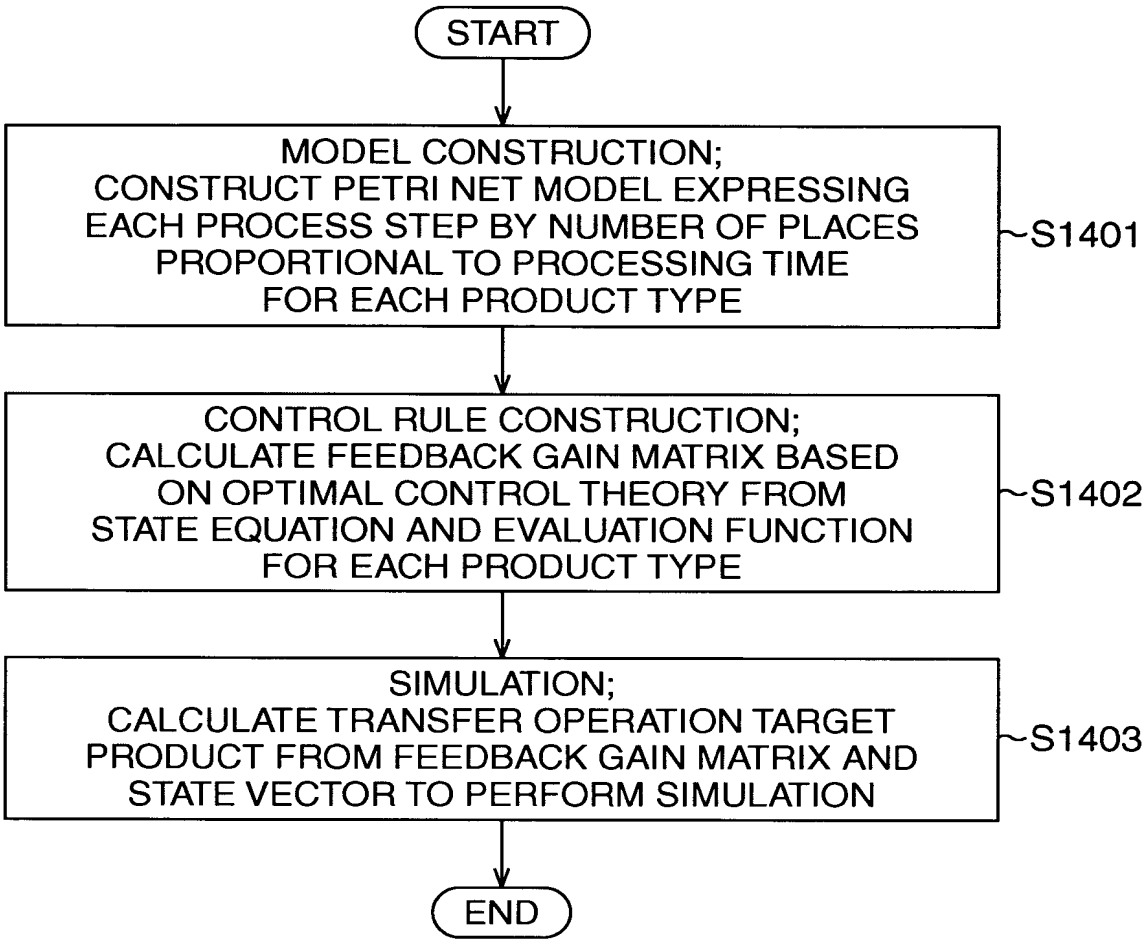

START
MODEL CONSTRUCTION;
CONSTRUCT PETRI NET MODEL EXPRESSING
EACH PROCESS STEP BY NUMBER OF PLACES
PROPORTIONAL TO PROCESSING TIME
FOR EACH PRODUCT TYPE
S1401
CONTROL RULE CONSTRUCTION;
CALCULATE FEEDBACK GAIN MATRIX BASED
ON OPTIMAL CONTROL THEORY FROM
STATE EQUATION AND EVALUATION FUNCTION
FOR EACH PRODUCT TYPE
S1402
SIMULATION;
CALCULATE TRANSFER OPERATION TARGET
PRODUCT FROM FEEDBACK GAIN MATRIX AND
STATE VECTOR TO PERFORM SIMULATION
S1403
END

FIG. 15

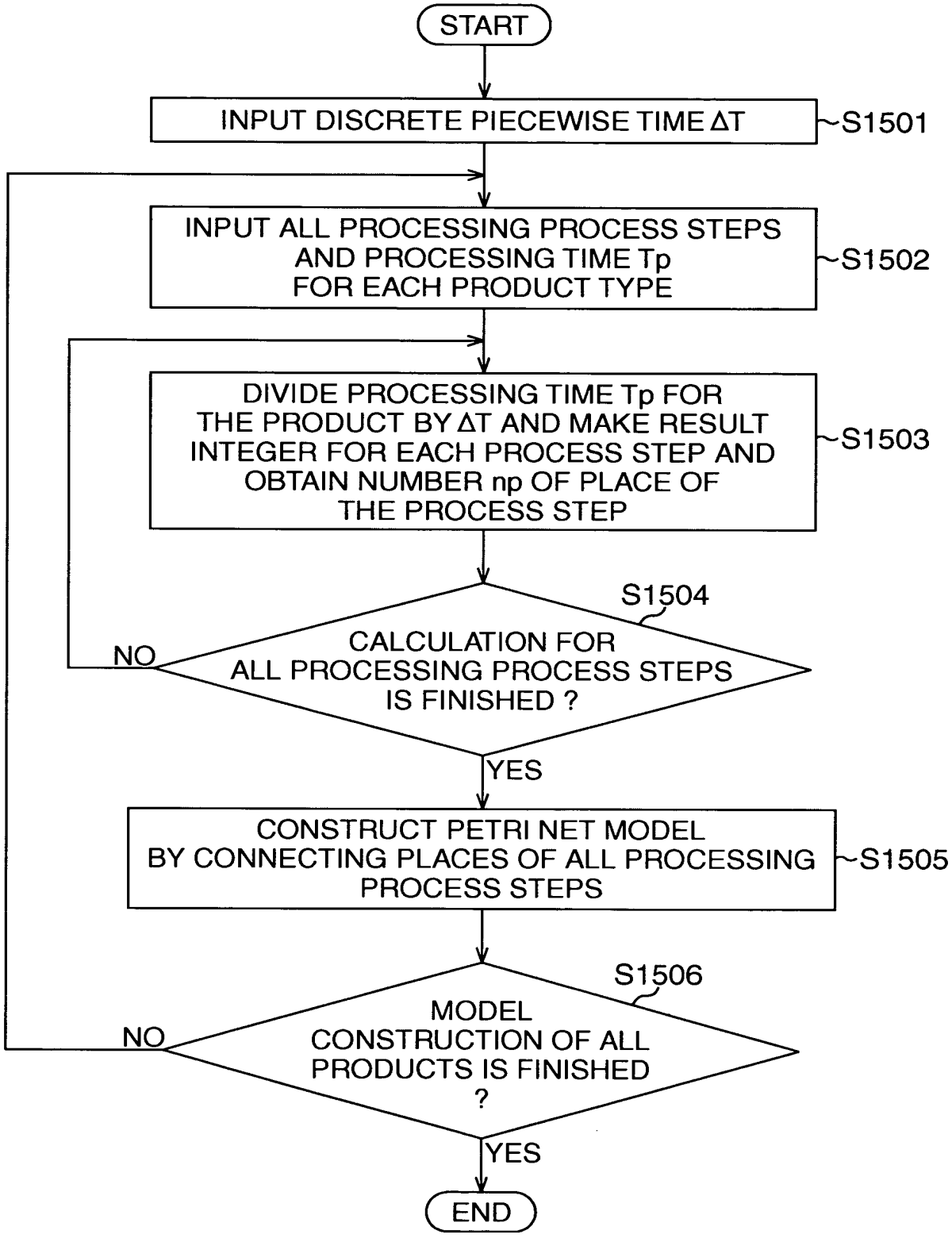

START
INPUT DISCRETE PIECEWISE TIME ΔT
S1501
INPUT ALL PROCESSING PROCESS STEPS AND PROCESSING TIME Tp FOR EACH PRODUCT TYPE
S1502
DIVIDE PROCESSING TIME Tp FOR THE PRODUCT BY ΔT AND MAKE RESULT INTEGER FOR EACH PROCESS STEP AND OBTAIN NUMBER np OF PLACE OF THE PROCESS STEP
S1503
S1504
CALCULATION FOR ALL PROCESSING PROCESS STEPS IS FINISHED ?
NO
YES
CONSTRUCT PETRI NET MODEL BY CONNECTING PLACES OF ALL PROCESSING PROCESS STEPS
S1505
S1506
MODEL CONSTRUCTION OF ALL PRODUCTS IS FINISHED ?
NO
YES
END

FIG. 16

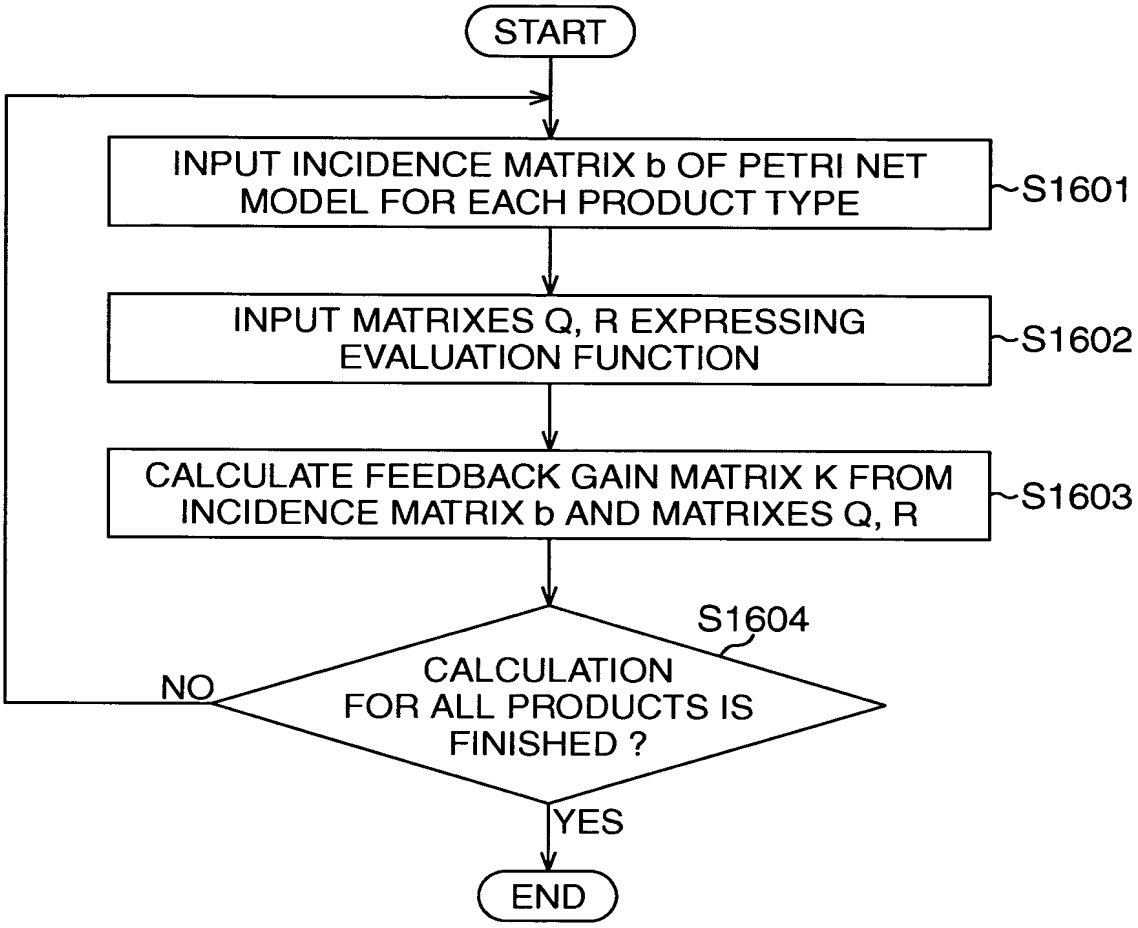

START
INPUT INCIDENCE MATRIX b OF PETRI NET MODEL FOR EACH PRODUCT TYPE
S1601
INPUT MATRIXES Q, R EXPRESSING EVALUATION FUNCTION
S1602
CALCULATE FEEDBACK GAIN MATRIX K FROM INCIDENCE MATRIX b AND MATRIXES Q, R
S1603
S1604
CALCULATION FOR ALL PRODUCTS IS FINISHED ?
NO
YES
END

FIG. 17

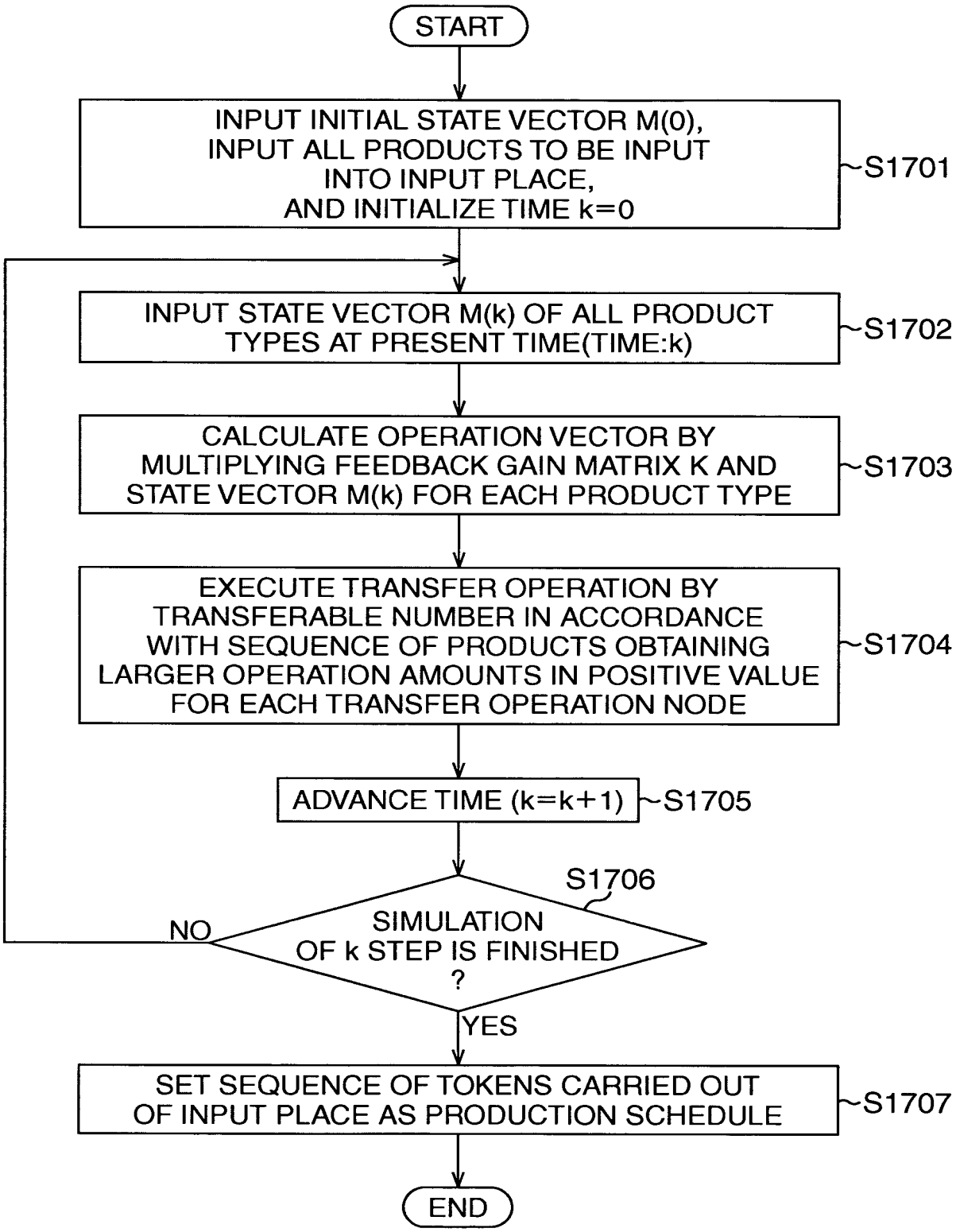

START
INPUT INITIAL STATE VECTOR M(0), INPUT ALL PRODUCTS TO BE INPUT INTO INPUT PLACE, AND INITIALIZE TIME k=0
S1701
INPUT STATE VECTOR M(k) OF ALL PRODUCT TYPES AT PRESENT TIME(TIME:k)
S1702
CALCULATE OPERATION VECTOR BY MULTIPLYING FEEDBACK GAIN MATRIX K AND STATE VECTOR M(k) FOR EACH PRODUCT TYPE
S1703
EXECUTE TRANSFER OPERATION BY TRANSFERABLE NUMBER IN ACCORDANCE WITH SEQUENCE OF PRODUCTS OBTAINING LARGER OPERATION AMOUNTS IN POSITIVE VALUE FOR EACH TRANSFER OPERATION NODE
S1704
ADVANCE TIME (k=k+1)
S1705
S1706
SIMULATION OF k STEP IS FINISHED ?
NO
YES
SET SEQUENCE OF TOKENS CARRIED OUT OF INPUT PLACE AS PRODUCTION SCHEDULE
S1707
END

FIG. 18

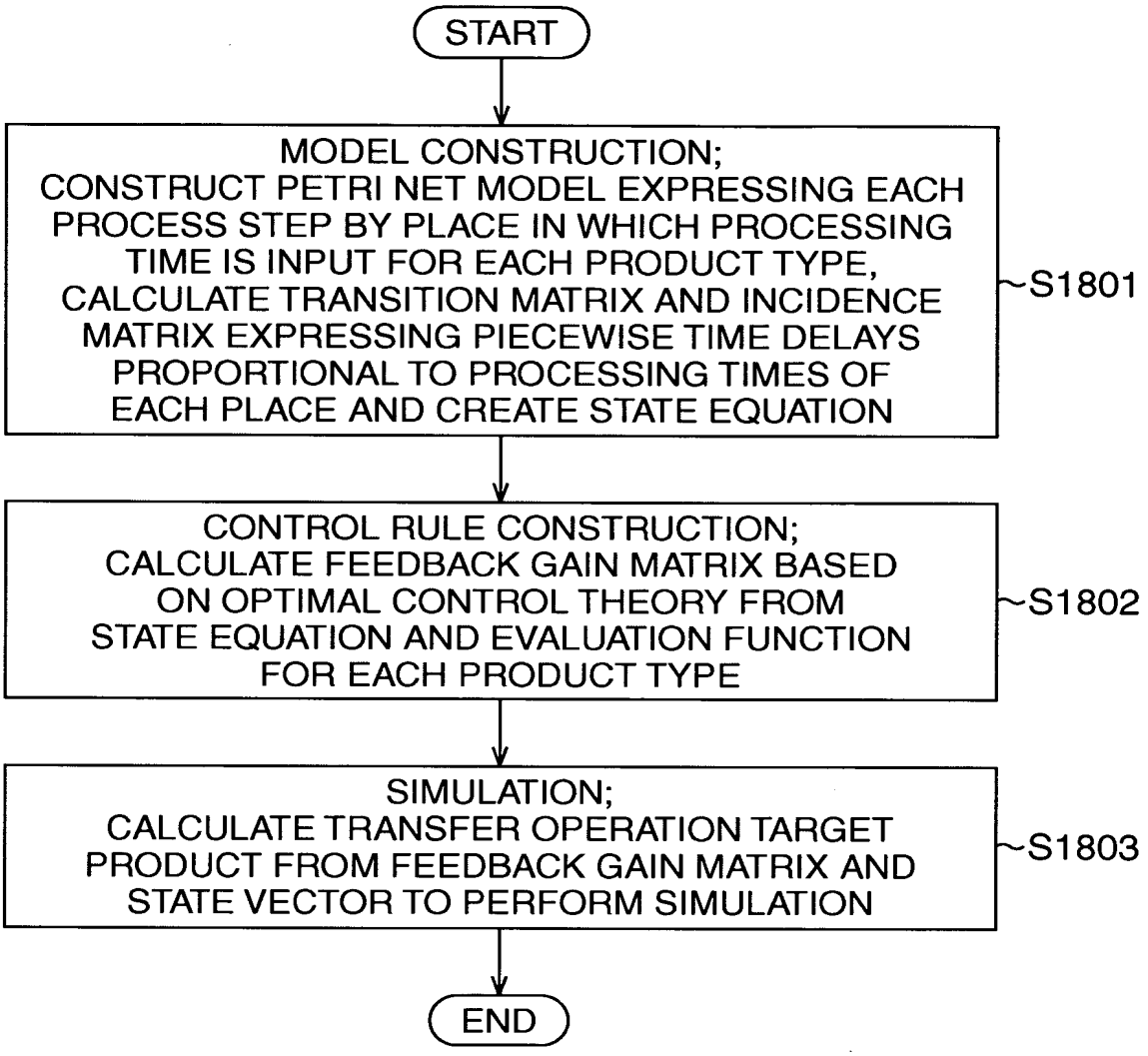

START
MODEL CONSTRUCTION;
CONSTRUCT PETRI NET MODEL EXPRESSING EACH PROCESS STEP BY PLACE IN WHICH PROCESSING TIME IS INPUT FOR EACH PRODUCT TYPE, CALCULATE TRANSITION MATRIX AND INCIDENCE MATRIX EXPRESSING PIECEWISE TIME DELAYS PROPORTIONAL TO PROCESSING TIMES OF EACH PLACE AND CREATE STATE EQUATION
S1801
CONTROL RULE CONSTRUCTION;
CALCULATE FEEDBACK GAIN MATRIX BASED ON OPTIMAL CONTROL THEORY FROM STATE EQUATION AND EVALUATION FUNCTION FOR EACH PRODUCT TYPE
S1802
SIMULATION;
CALCULATE TRANSFER OPERATION TARGET PRODUCT FROM FEEDBACK GAIN MATRIX AND STATE VECTOR TO PERFORM SIMULATION
S1803
END

FIG. 19

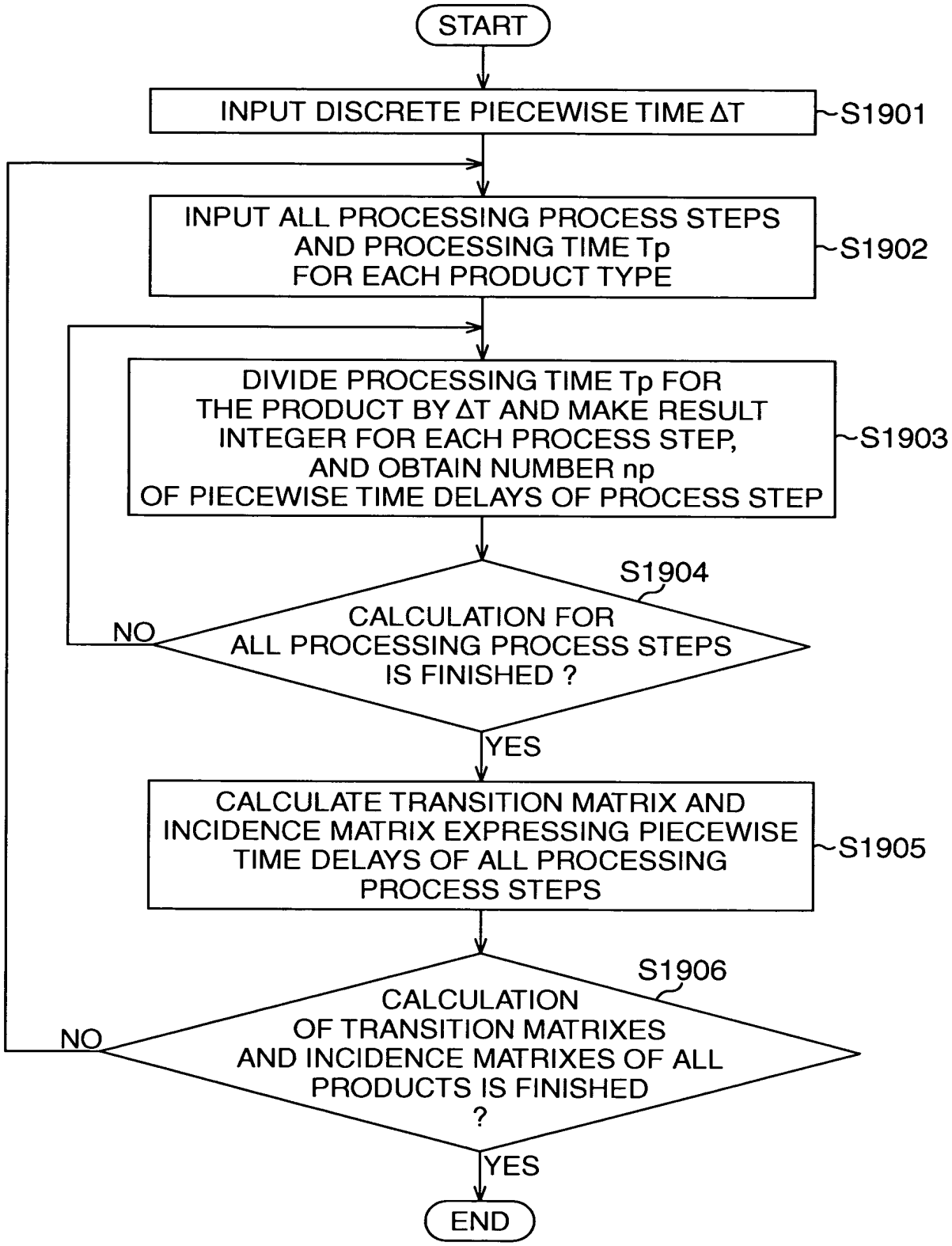

START
INPUT DISCRETE PIECEWISE TIME ΔT
S1901
INPUT ALL PROCESSING PROCESS STEPS AND PROCESSING TIME Tp FOR EACH PRODUCT TYPE
S1902
DIVIDE PROCESSING TIME Tp FOR THE PRODUCT BY ΔT AND MAKE RESULT INTEGER FOR EACH PROCESS STEP, AND OBTAIN NUMBER np OF PIECEWISE TIME DELAYS OF PROCESS STEP
S1903
S1904
CALCULATION FOR ALL PROCESSING PROCESS STEPS IS FINISHED ?
NO
YES
CALCULATE TRANSITION MATRIX AND INCIDENCE MATRIX EXPRESSING PIECEWISE TIME DELAYS OF ALL PROCESSING PROCESS STEPS
S1905
S1906
CALCULATION OF TRANSITION MATRIXES AND INCIDENCE MATRIXES OF ALL PRODUCTS IS FINISHED ?
NO
YES
END

FIG. 20

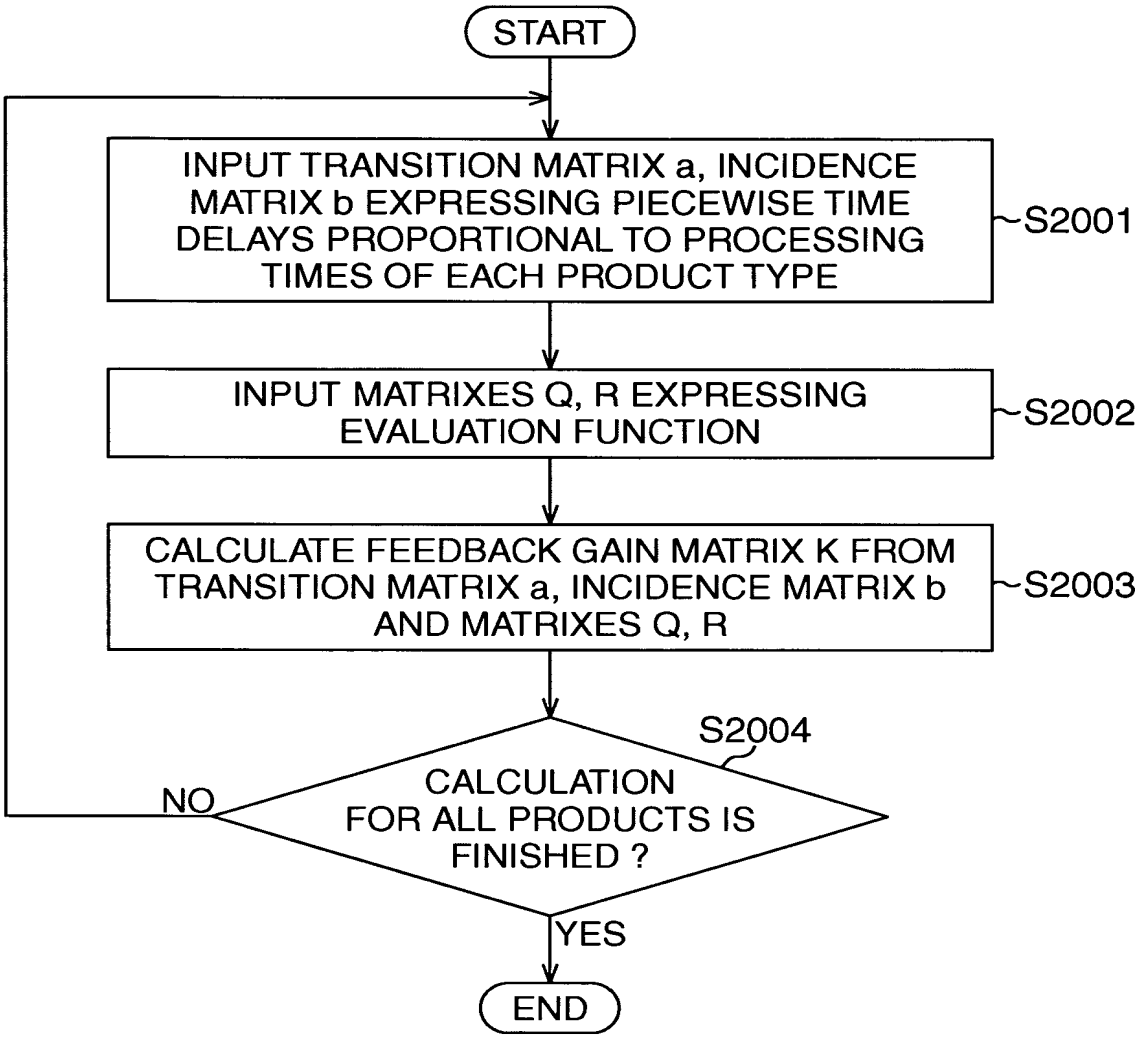

START
INPUT TRANSITION MATRIX a, INCIDENCE MATRIX b EXPRESSING PIECEWISE TIME DELAYS PROPORTIONAL TO PROCESSING TIMES OF EACH PRODUCT TYPE
S2001
INPUT MATRIXES Q, R EXPRESSING EVALUATION FUNCTION
S2002
CALCULATE FEEDBACK GAIN MATRIX K FROM TRANSITION MATRIX a, INCIDENCE MATRIX b AND MATRIXES Q, R
S2003
S2004
CALCULATION FOR ALL PRODUCTS IS FINISHED ?
NO
YES
END

FIG. 21

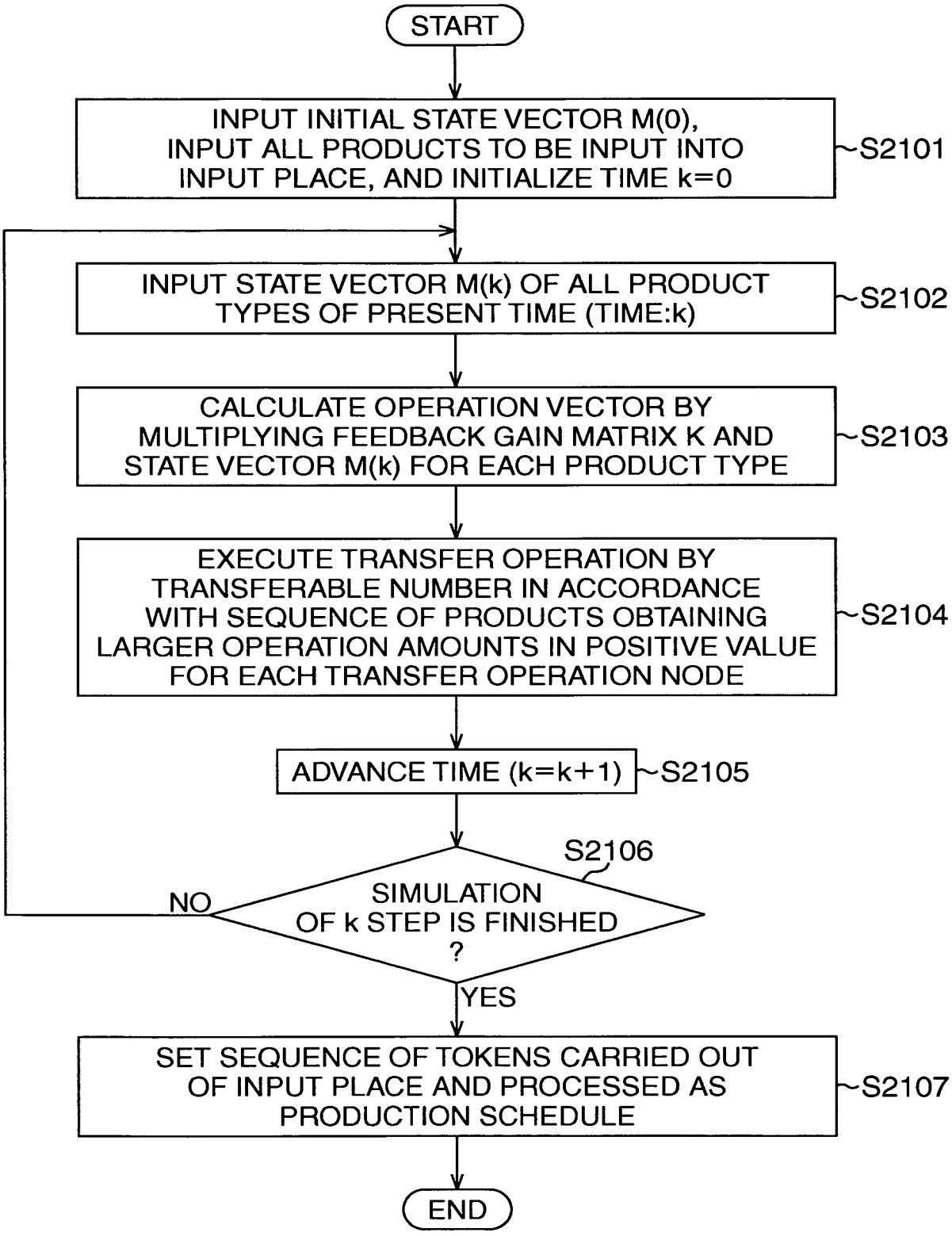

START
INPUT INITIAL STATE VECTOR M(0), INPUT ALL PRODUCTS TO BE INPUT INTO INPUT PLACE, AND INITIALIZE TIME k=0
S2101
INPUT STATE VECTOR M(k) OF ALL PRODUCT TYPES OF PRESENT TIME (TIME:k)
S2102
CALCULATE OPERATION VECTOR BY MULTIPLYING FEEDBACK GAIN MATRIX K AND STATE VECTOR M(k) FOR EACH PRODUCT TYPE
S2103
EXECUTE TRANSFER OPERATION BY TRANSFERABLE NUMBER IN ACCORDANCE WITH SEQUENCE OF PRODUCTS OBTAINING LARGER OPERATION AMOUNTS IN POSITIVE VALUE FOR EACH TRANSFER OPERATION NODE
S2104
ADVANCE TIME (k=k+1)
S2105
S2106
SIMULATION OF k STEP IS FINISHED ?
NO
YES
SET SEQUENCE OF TOKENS CARRIED OUT OF INPUT PLACE AND PROCESSED AS PRODUCTION SCHEDULE
S2107
END

FIG. 22

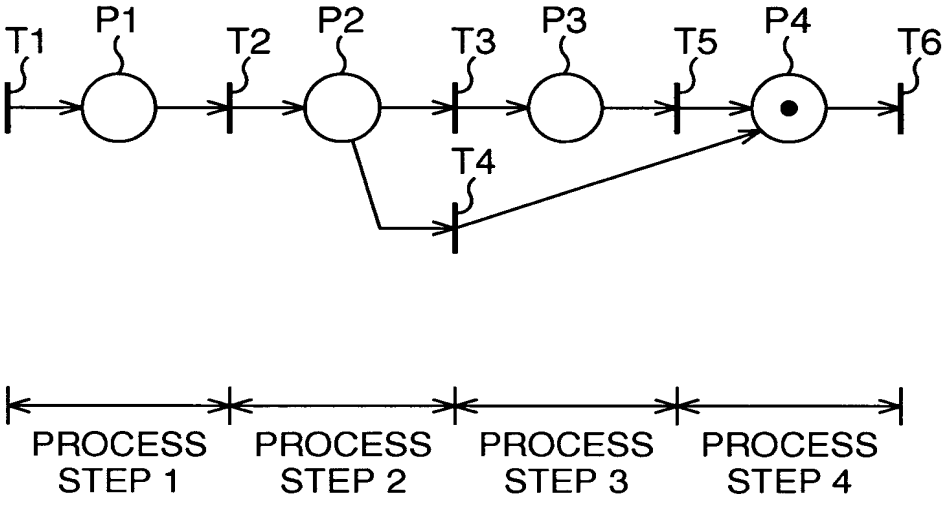

T1
P1
T2
P2
T3
P3
T5
P4
T6
T4
PROCESS STEP 1
PROCESS STEP 2
PROCESS STEP 3
PROCESS STEP 4

FIG. 23

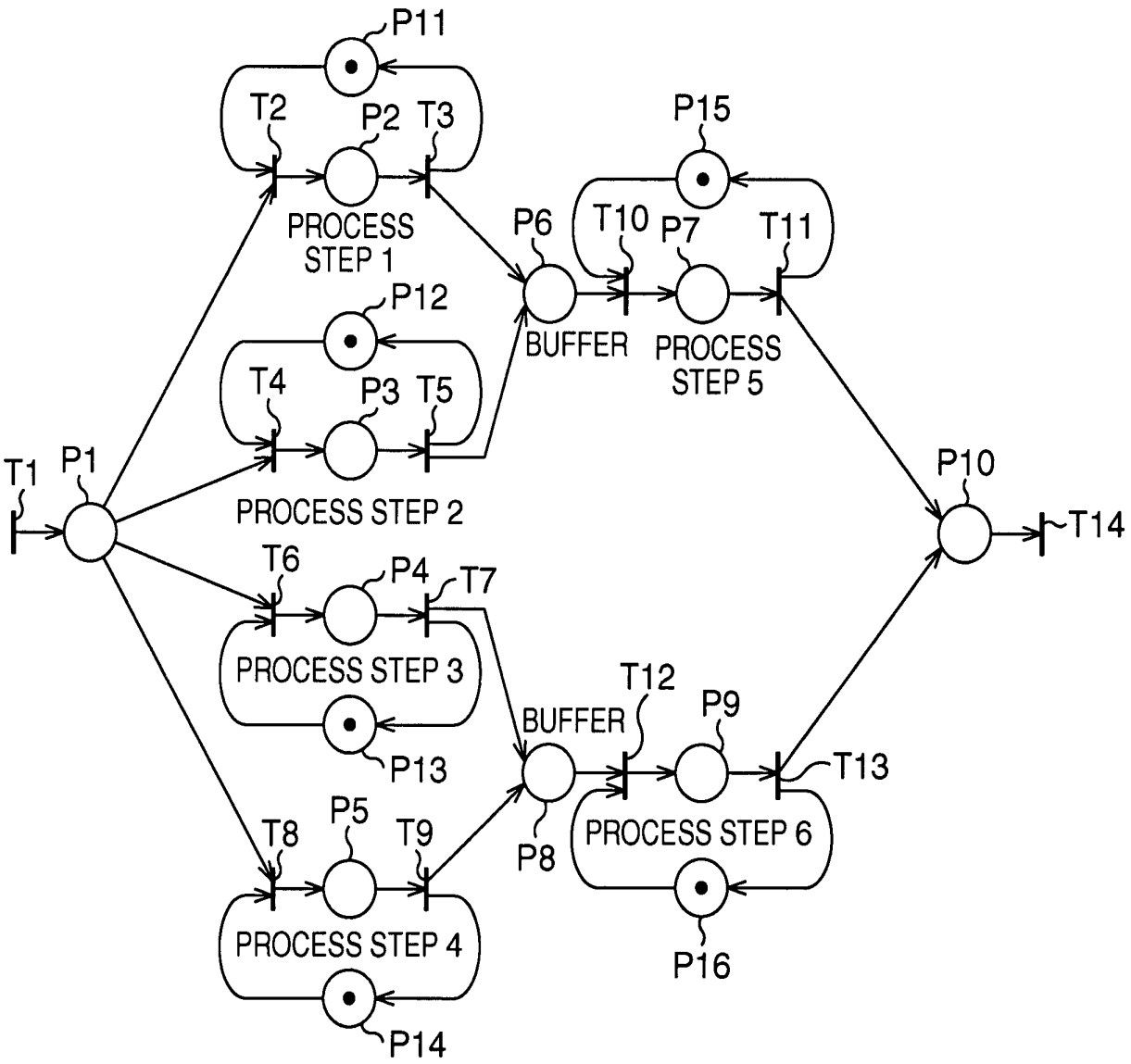

P11
T2
P2
T3
PROCESS STEP 1
P15
T10
P7
T11
P6
BUFFER
PROCESS STEP 5
P12
T4
P3
T5
T1
P1
PROCESS STEP 2
P10
T14
T6
P4
T7
PROCESS STEP 3
P13
T12
BUFFER
P9
T13
P5
T8
T9
P8
PROCESS STEP 6
PROCESS STEP 4
P16
P14

FIG. 24

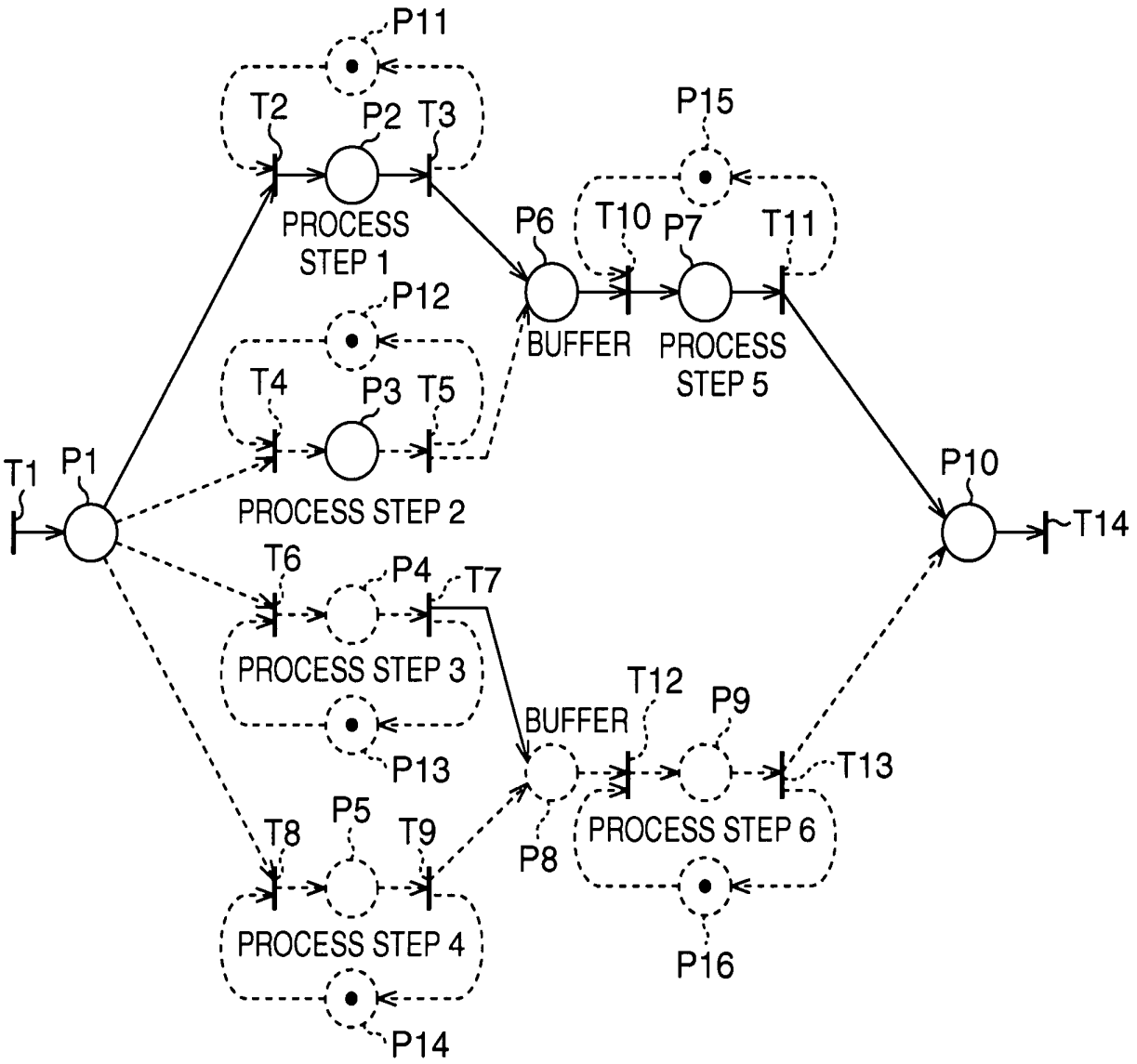

P11
T2
P2
T3
PROCESS STEP 1
P15
T10
P6
P7
T11
BUFFER
PROCESS STEP 5
P12
T4
P3
T5
PROCESS STEP 2
T1
P1
P10
T14
T6
P4
T7
PROCESS STEP 3
P13
T12
BUFFER
P9
T13
T8
P5
T9
P8
PROCESS STEP 6
PROCESS STEP 4
P16
P14

FIG. 25

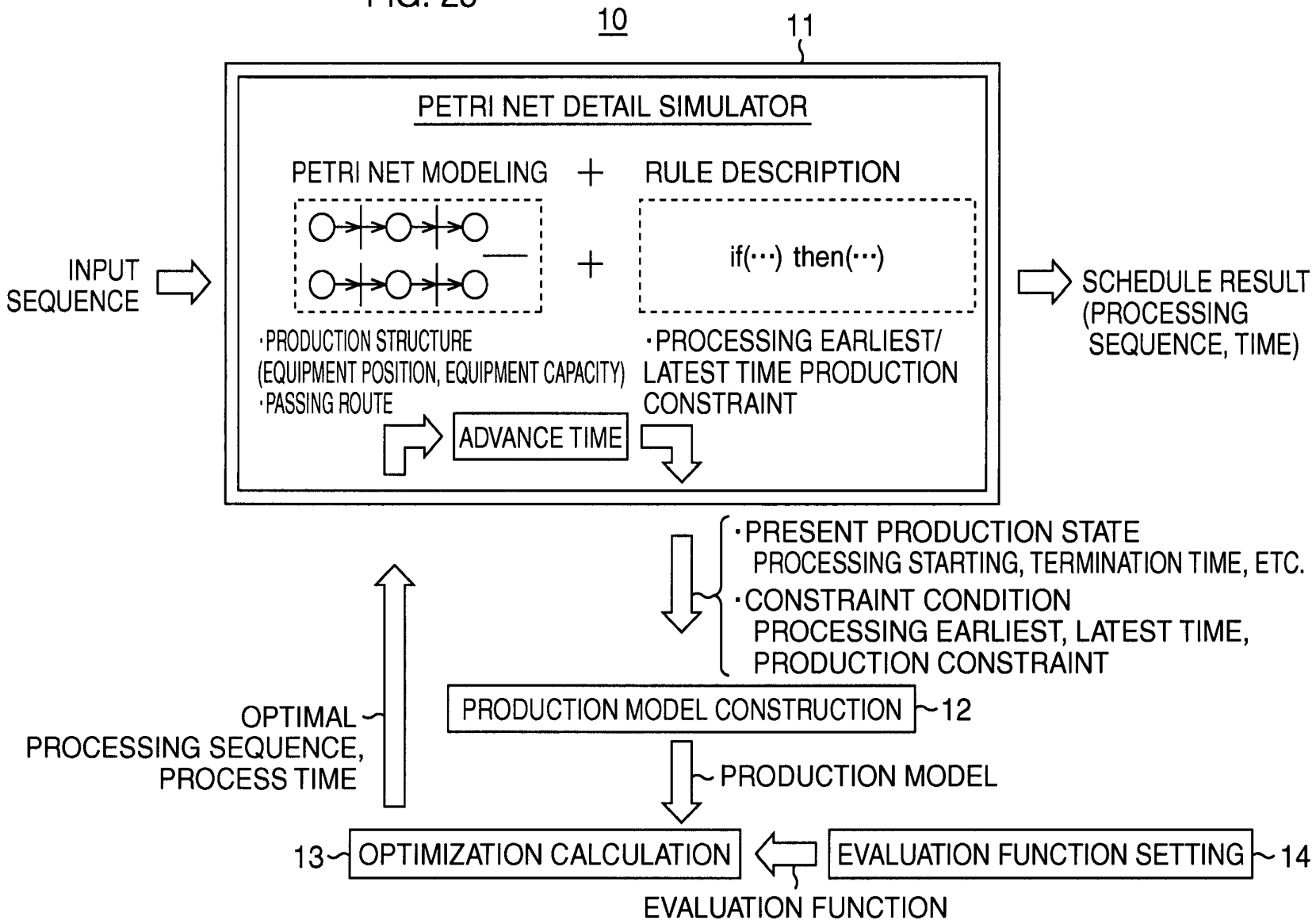
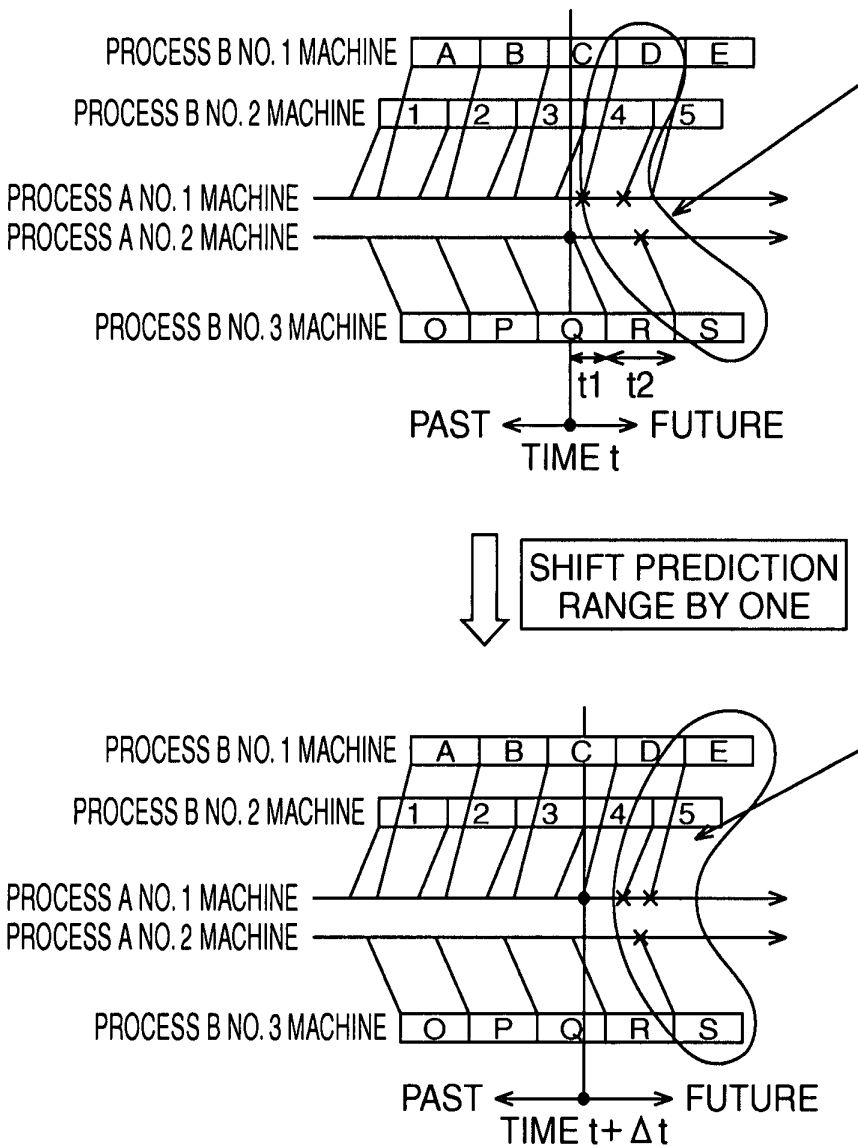

10
11
PETRI NET DETAIL SIMULATOR
PETRI NET MODELING
+
RULE DESCRIPTION
INPUT SEQUENCE
if(···) then(···)
SCHEDULE RESULT (PROCESSING SEQUENCE, TIME)
·PRODUCTION STRUCTURE (EQUIPMENT POSITION, EQUIPMENT CAPACITY)
·PASSING ROUTE
·PROCESSING EARLIEST/ LATEST TIME PRODUCTION CONSTRAINT
ADVANCE TIME
·PRESENT PRODUCTION STATE PROCESSING STARTING, TERMINATION TIME, ETC.
·CONSTRAINT CONDITION PROCESSING EARLIEST, LATEST TIME, PRODUCTION CONSTRAINT
OPTIMAL PROCESSING SEQUENCE, PROCESS TIME
PRODUCTION MODEL CONSTRUCTION
12
PRODUCTION MODEL
13
OPTIMIZATION CALCULATION
EVALUATION FUNCTION SETTING
14
EVALUATION FUNCTION

FIG. 26


PROCESS B NO. 1 MACHINE
A
B
C
D
E
PROCESS B NO. 2 MACHINE
1
2
3
4
5
PROCESS A NO. 1 MACHINE
PROCESS A NO. 2 MACHINE
PROCESS B NO. 3 MACHINE
O
P
Q
R
S
t1
t2
PAST
FUTURE
TIME t
SHIFT PREDICTION RANGE BY ONE
PROCESS B NO. 1 MACHINE
A
B
C
D
E
PROCESS B NO. 2 MACHINE
1
2
3
4
5
PROCESS A NO. 1 MACHINE
PROCESS A NO. 2 MACHINE
PROCESS B NO. 3 MACHINE
O
P
Q
R
S
PAST
FUTURE
TIME t+Δt

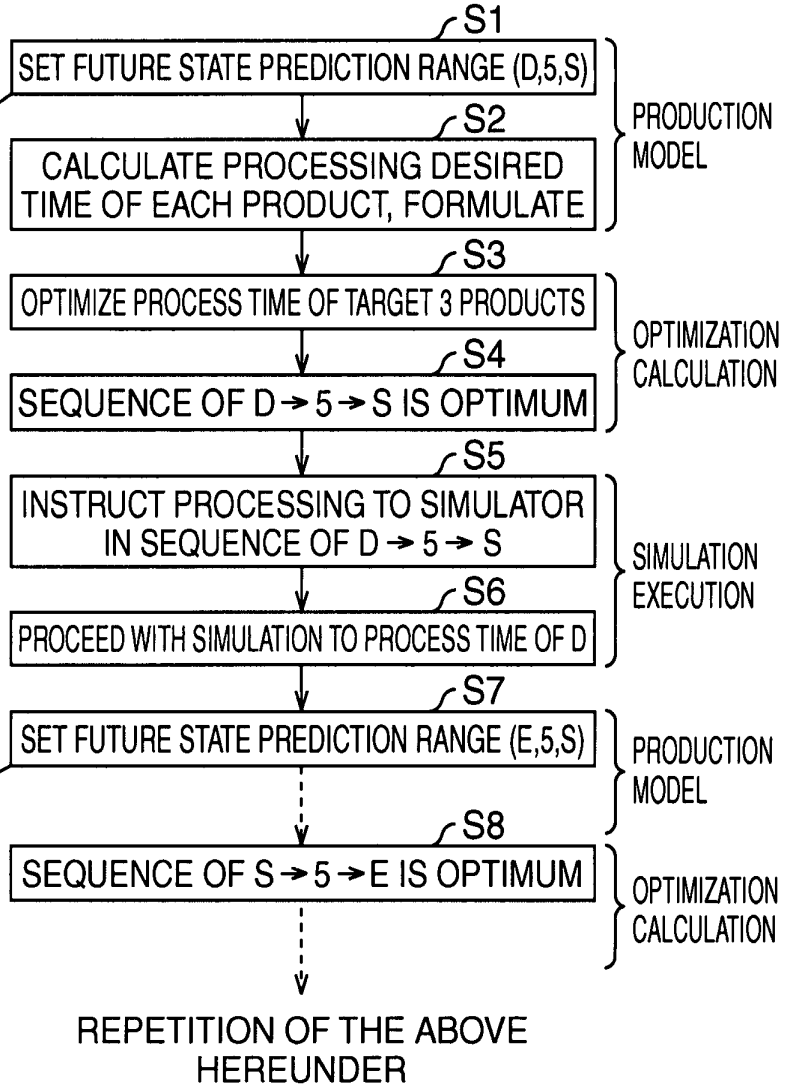

S1
SET FUTURE STATE PREDICTION RANGE (D,5,S)
S2
CALCULATE PROCESSING DESIRED TIME OF EACH PRODUCT, FORMULATE
PRODUCTION MODEL
S3
OPTIMIZE PROCESS TIME OF TARGET 3 PRODUCTS
S4
SEQUENCE OF D → 5 → S IS OPTIMUM
OPTIMIZATION CALCULATION
S5
INSTRUCT PROCESSING TO SIMULATOR IN SEQUENCE OF D → 5 → S
S6
PROCEED WITH SIMULATION TO PROCESS TIME OF D
SIMULATION EXECUTION
S7
SET FUTURE STATE PREDICTION RANGE (E,5,S)
PRODUCTION MODEL
S8
SEQUENCE OF S → 5 → E IS OPTIMUM
OPTIMIZATION CALCULATION
REPETITION OF THE ABOVE HEREUNDER

FIG. 27

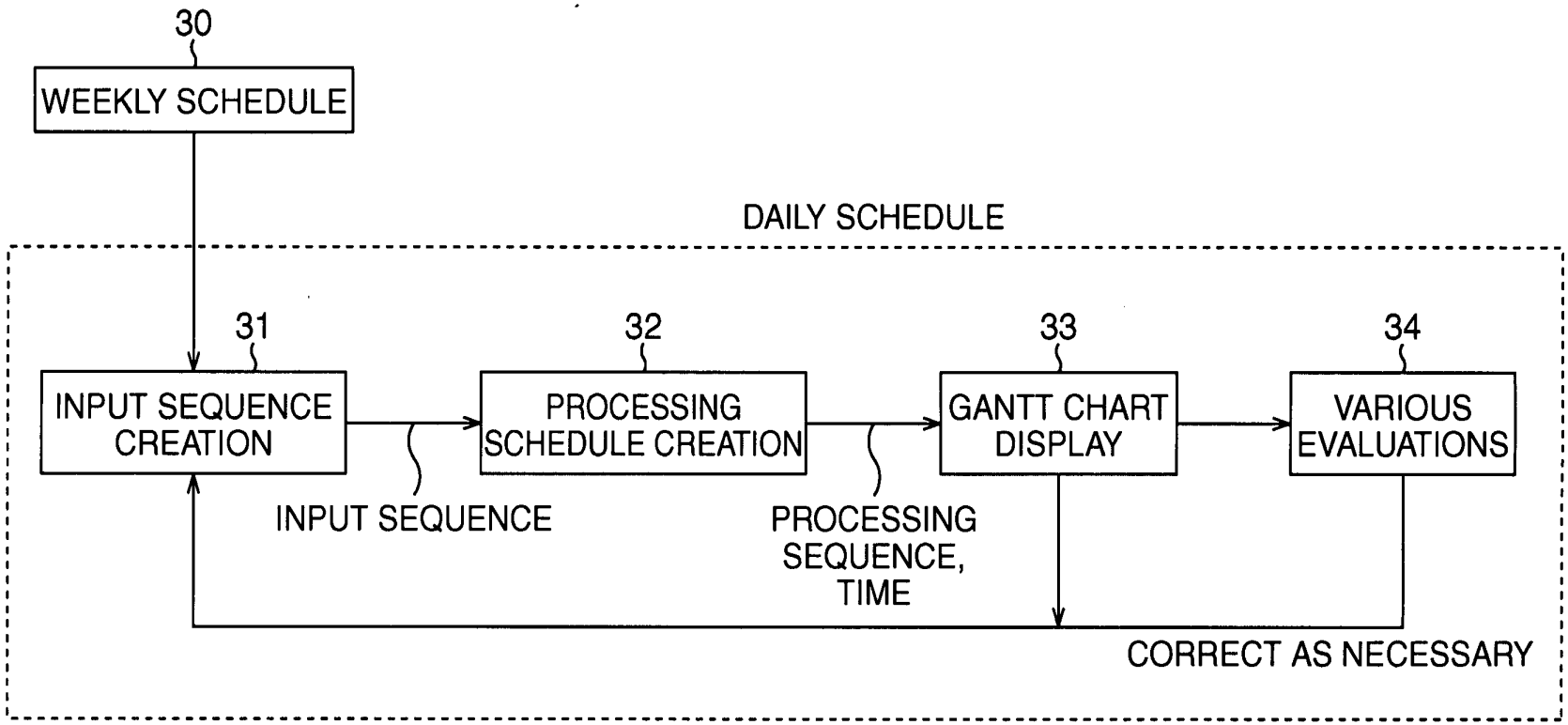

30
WEEKLY SCHEDULE
DAILY SCHEDULE
31
32
33
34
INPUT SEQUENCE CREATION
PROCESSING SCHEDULE CREATION
GANTT CHART DISPLAY
VARIOUS EVALUATIONS
INPUT SEQUENCE
PROCESSING SEQUENCE, TIME
CORRECT AS NECESSARY

FIG. 28

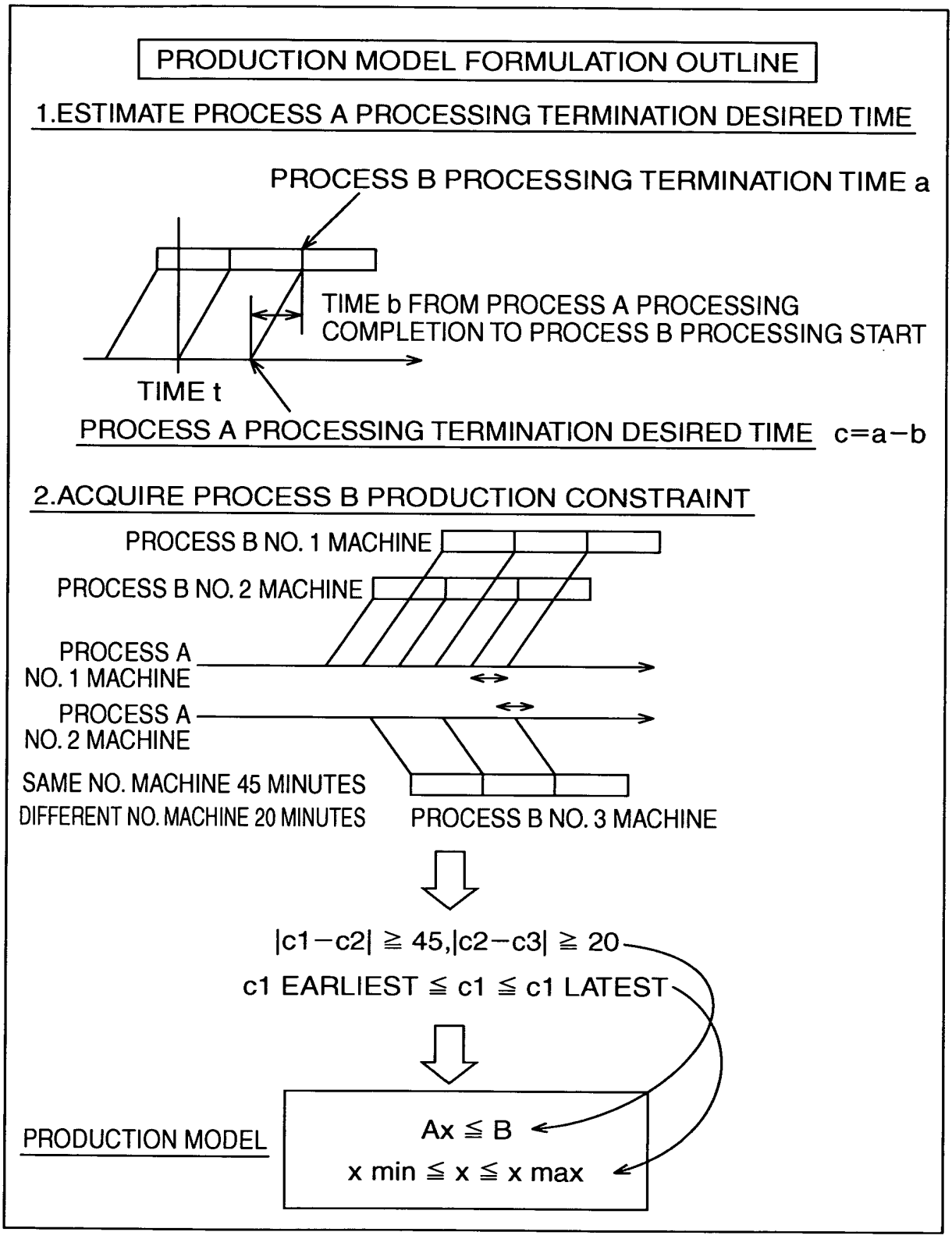
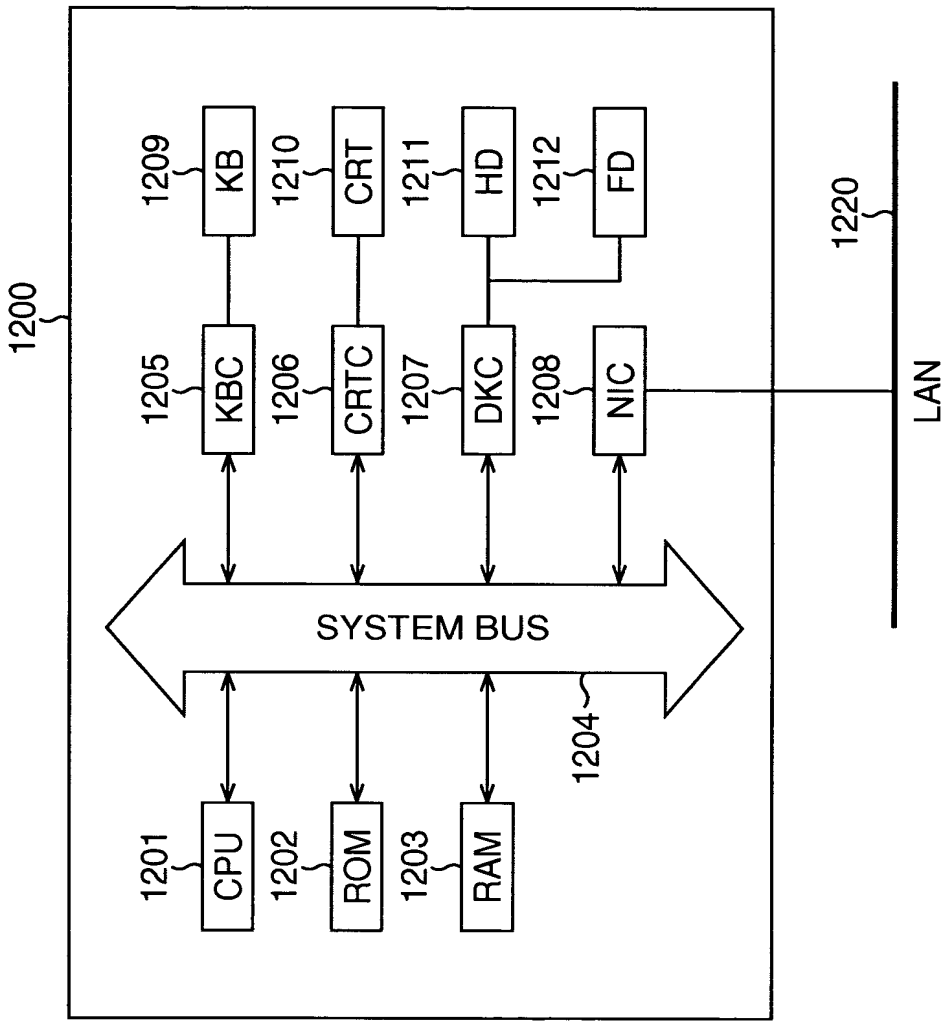

PRODUCTION MODEL FORMULATION OUTLINE
1.ESTIMATE PROCESS A PROCESSING TERMINATION DESIRED TIME
PROCESS B PROCESSING TERMINATION TIME a
TIME b FROM PROCESS A PROCESSING COMPLETION TO PROCESS B PROCESSING START
TIME t
PROCESS A PROCESSING TERMINATION DESIRED TIME c=a−b
2.ACQUIRE PROCESS B PRODUCTION CONSTRAINT
PROCESS B NO. 1 MACHINE
PROCESS B NO. 2 MACHINE
PROCESS A NO. 1 MACHINE
PROCESS A NO. 2 MACHINE
SAME NO. MACHINE 45 MINUTES
DIFFERENT NO. MACHINE 20 MINUTES
PROCESS B NO. 3 MACHINE
|c1−c2| ≧ 45,|c2−c3| ≧ 20
c1 EARLIEST ≦ c1 ≦ c1 LATEST
PRODUCTION MODEL
Ax ≦ B
x min ≦ x ≦ x max

FIG. 29


1200
1201
CPU
1202
ROM
1203
RAM
1204
SYSTEM BUS
1205
KBC
1206
CRTC
1207
DKC
1208
NIC
1209
KB
1210
CRT
1211
HD
1212
FD
1220
LAN